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THE Spanish cruiser *Reina Regente*, an engraving of which will be found on another page, has developed extraordinary speed, having run at the rate of over 20 knots an hour on the measured course in fairly smooth water. This is, of course, a greater speed than could be maintained for long distances or at sea, but it shows sufficiently that the ship is capable of making very fast time under any ordinary circumstances.

Two or three of the new cruisers now under contract for our own Navy are required by the specifications to make 19 knots an hour. If they can do this, and there is no doubt that the contract can be carried out, they will rank with the *Reina Regente* and a few others as the fastest warships afloat. The advantages of speed in a cruiser are too many and are too evident to need recapitulation here, and the possession of even a few such vessels would be of very great advantage in case of war.

Very few people realize how few vessels there are which can make the time indicated by these figures. It does not seem an extraordinary statement to say that a steamer can make 19 knots an hour; but 19 knots is very nearly 22 statute miles, or ordinary railroad speed. Very few even of the fastest trans-Atlantic steamers can do better than this, or even as well; and we cannot recall more than three or four existing warships which can come up to it.

LIKE the new Spanish cruiser, the Spanish torpedo-boats illustrated and described elsewhere have shown extraordinary speed and are almost, if not quite, the fastest vessels afloat. There is, however, a material difference between them and the cruiser. The torpedo-boat is a machine in which almost everything else is sacrificed to obtain great speed. It is not designed for long runs, and is not expected to keep up its extraordinary pace for any great distance, and accordingly has no great capacity for fuel or stores and but scanty provision for comfort of crew or officers. In a word the torpedo-boat is simply an enlargement of the floating or submarine torpedo, and is rather a marine projectile than a cruising vessel. That it must be fast is a necessity, and everything else is subordinate to this consideration.

IN his annual report to the Secretary of the Navy, Admiral Porter advocates strongly some plan which may secure the building of merchant vessels of a class which could be readily converted into naval cruisers in case of need. The Admiral takes very much the same ground on this point as was assumed in a recent article in this column, and enforces his conclusions by a reference to foreign experience.

AN important change in the method of charging for the use of freight cars on foreign lines has been adopted by the Pennsylvania and several other leading companies, and seems to be in a fair way to come into general use. Heretofore the settlements between the companies have been made entirely on the basis of the mileage traveled by a car, the usual rate for some years past having been three-quarters of a cent per mile. This plan has the defects that under it a car earns nothing unless it is in motion, and also that a company has no inducement to hasten the return of a car belonging to another line, but can hold it in a yard or at a way station as long as it pleases without incurring extra charges.

Under the new system a mixed charge of one-half cent a mile and 15 cents a day is substituted for the simple charge of three-quarters of a cent per mile. By this arrangement a car which is side-tracked will at least be earning the 15 cents a day for its owner, and this time charge, which will rise in the aggregate to a considerable amount for companies handling many foreign cars, will be a substantial inducement to hasten the loading and unloading of cars and their return to their owners.

A subordinate feature of the change is that the *per diem* rate will be charged on cars sent to shop for repairs and on cars destroyed until date of notice to owners, thus enforcing the necessity of prompt notification in the case of cars damaged or destroyed, a matter now too often neglected.

The new system has been urged on the railroads by the Car Accountants' Association, a body which has been very active in its department, and has done much creditable work. It is to be hoped that it will result in fulfilling the expectations entertained of it, and will put a stop to the many delays now encountered in moving freight cars.

THE latest addition to Panama Canal literature is a report from Señor N. T. Armero, the Agent of the Colombian Government in its dealings with the Canal Company. Señor Armero is inclined to hope that the skill of the managers of the company, backed by French national pride, will secure the completion of the canal hereafter. The facts which he presents in his report, however, corroborate fully the discouraging accounts heretofore published. He says that only about one-fifth of the estimated amount of excavation of the canal has been done, and that on the easier portions of the work, and points out that the two most difficult and expensive portions of the work—the excavation of the Culebra section and the diversion of the Chagres River—have barely been touched yet. He believes further that the amount of money still needed is nearly four times that already spent, and his estimate brings the cost of the canal almost up to $800,000,000. He asserts also, as the result of his observations, that the number of men employed by the company has never been as great as claimed, and that now many sections of the work are almost deserted.

M. de Lesseps has recently announced that the canal is to be opened by February, 1890, but says that it will not then be entirely completed, although sufficiently far advanced to permit the passage of vessels. This announcement is probably meant to encourage French investors in the securities of the Canal Company; it does not seem to be seriously received anywhere by those who have any knowledge of the real condition of things on the Isthmus.

AN increase in the speed of trans-continental trains has been made on the Union and Northern Pacific routes, the gain on the Union Pacific being 15½ hours, of which 10 hours is made between Omaha and Ogden, on the Union Pacific's own line, and 5½ hours between Ogden and San Francisco, on the Central Pacific road. The gain on the Northern Pacific by the new fast train is 18¾ hours between St. Paul and Portland. The Southern Pacific and the Atlantic & Pacific lines make no change.

The Pacific railroad lines have never made any special attempt to secure fast time on their regular trains. By the schedule lately in force the Northern Pacific express trains took about 91 hours to run the 1,913 miles from St. Paul to Portland, giving an average of about 21 miles an hour, without allowing for stops. By the Union Pacific route trains took 86½ hours to run 1,866 miles, giving an average speed of 21½ miles, also without allowing for stops.

The new schedules, making the time 71 hours on either line, will give average runs of 27 miles an hour by the Northern and 26¼ miles by the Union-Central Pacific route. Even after making the necessary allowance for stops, this will not require any very fast running.

HEATING cars by steam from the locomotive is to be tried to a considerable extent this winter, and there is no doubt that before spring we shall have a very fair idea of its merits and defects in actual practice. The New York Central & Hudson River Company will soon have a number of its local trains equipped and will probably extend the application of the system. The Pennsylvania Railroad, it is understood, is preparing to do a good deal of work in the same direction, and other companies are following. Several of the systems of continuous heating have met with favor and will be put into service quite extensively, and there will probably be an active discussion of their respective merits, even after a term of service has tried them.

The adoption of steam heating, indeed, seems likely to be so general that several important companies have thought it well to consult as to the question of adopting uniform couplings for the steam-pipes in the cars. This is a question of considerable importance and well deserves attention now, when it will be comparatively easy to secure uniformity, and so avoid the many troubles and annoyances which will be sure to arise later. There are several systems of continuous heating which seem to possess merit, and it is not likely that any one of them will secure general adoption to the exclusion of all the others, but there should be no great difficulties in the way of adopting at least a uniform coupling now. At any rate the obstacles to such action are necessarily less formidable at present, than they would be by-and-by, when a large number of cars may be equipped with different patterns, requiring a considerable expenditure to make changes.

THE much vexed question of the increase of terminal facilities of the Brooklyn Bridge is to be referred to a new commission of experts, who are to consider the plans already submitted to the Bridge Trustees. The need of greater facilities for the reception and discharge of passengers on the Bridge railroad is a pressing one, and some measures of relief should be adopted as soon as possible.

The question is not an easy one to solve, combining the conditions of a necessarily limited space, an enormous traffic compressed within a few hours of the day and the consequent need of an almost continuous movement of trains with the least possible waste of time in loading, unloading and shifting, and finally the necessity of avoiding all possibility of accident. There is no precedent by which to go, for even the New York elevated railroads have more room to turn their trains, do not require to turn them so frequently and have at least the advantage of independent motors, whose number can be increased, while the Bridge traffic is subject to the limitations of the cable system.

There has been some difficulty in getting experts who are qualified to serve on the commission, chiefly because their number is limited and their time very fully occupied. The commission as finally made made up, however, is a very capable and satisfactory one; it consists of Colonel Julius W. Adams, of Brooklyn; Mr. Joseph Crawford, Superintendent of the New York Division of the Pennsylvania Railroad; and Mr. Walter Katte, Chief Engineer of the New York Central & Hudson River Railroad.

A BRIDGE over the Hudson River at New York is an idea which has doubtless occurred to many, only to be dismissed as impracticable. Such a structure is now seriously proposed, however, the leading projectors being T. A. Potts, of the New York, Susquehanna & Western Railroad, and Bird W. Spencer. Their plan is for a structure on the cantilever system, with a central span of 725 ft., to be high enough above the water to permit the passage of the largest vessels. The proposed place is from Stevens' Point, just above Hoboken, to a point in the city near Forty-second Street.

The project at present is in its earliest stages and can

hardly be said to have even taken definite form. It must pass through a long stage of discussion before it reaches a point where it is to be regarded even as a probability, and it does not appear likely that the actual construction of a bridge will be began for a long time yet. Certainly such a structure would be desirable, but there are so many difficulties in the way that it is not easy now to see how they can be overcome.

THE election of Professor Samuel P. Langley to the important post of Secretary of the Smithsonian Institute was generally expected. Professor Langley has been for some time Assistant Secretary and has discharged the duties of the office since the late Professor Baird was compelled by his failing health to give up the work.

The new Secretary is in the prime of life and has a high reputation as a scientist, based upon valuable researches, chiefly in the department of solar physics. He has also shown much ability as an organizer and director while in charge of the Allegheny Observatory and elsewhere. His ability has been generally recognized both in this country and abroad.

SPECIFICATIONS FOR CAST-IRON CAR WHEELS.

DURING the session of the last convention of the Master Car-Builders' Association, a meeting of car-wheel manufacturers was held at the same time and place. One of the objects of this meeting, it was said, was "to consider how to give railroad companies the best wheels for the least money." The wheel-makers appeared before the Master Car-Builders' Association with Mr. Whitney, of Philadelphia, as their spokesman, who asked that a committee be appointed by the Master Car-Builders to confer with the wheel-makers, and said that the Master Mechanics', and perhaps some other railroad associations, would be requested to do the same thing, and that these committees, with the wheel-makers, would form a joint committee to consider the whole question of the use of wheels, the guaranteeing of the mileage, and the defects of wheels which result from usage, and defects that are due to the manufacture.

The Master Car-Builders' Association appointed such a committee, and no doubt some action—such as is outlined above—will be taken before the next convention.

There can be no doubt of the fact that good cast-iron wheels are very safe and reliable, and will very seldom fail by breaking. On the other hand, it is equally certain that large numbers of the wheels which are made and put into service do break and cause accidents more or less serious. It is, therefore, of the utmost importance that wheels should be subjected to inspection and tests, which will determine whether they are good or bad, and that when wheels are bought, the tests to which they will be subjected and must conform should be specified. No doubt the very excellent committee which has been appointed will be able, in consultation with the wheel manufacturers, to prepare specifications which will insure that wheels made in conformity therewith will be reliable. Probably, too, if those who will consider this subject will formulate their knowledge of wheel manufacture, and their experience in their use, into the shape of complete specifications, it would result in railroad companies getting better wheels than ever before. The Joint Committee, therefore, has a very important duty to perform, and if they do what from their knowledge and experience of the subject may not unreasonably be expected of them, their action ought to be instrumental in preventing many accidents and do a great deal to make travel and traffic on railroads safer and surer.

But it will be six months before the next annual convention of the Master Car-Builders' Association meets, and before any action can be taken on the Committee's report. In the meanwhile railroad companies must use and order wheels. It is essential that many of them should do something at once to improve the quality of the wheels they are buying. If they can do nothing better, such companies would do well to adopt the specifications of the Pennsylvania Railroad, which are printed on another page, until the Joint Committee referred to makes its report and the Master Car-Builders' Association takes action on it.

But it does not matter what specifications are adopted, the mere *adoption* of them will do little good, if those who buy the wheels do not take steps to secure conformity to the requirements of the specifications. This means that some system of testing and inspection must be adopted to determine whether wheels furnished are up to the requirements. To use a Hibernian expression, "to say this is easy but to do it?" There are always influences in and about a railroad company which somehow or other seem naturally to array themselves against any faithful and honest system of testing. If an officer of a railroad company, who is the inspector or the inspector's boss, owns stock in the foundry which furnishes the wheels, his judgment and impartiality are apt to be perverted. If the inspector is amenable to the influence of gifts and bribes, in time he will become judicially and morally color-blind, so to speak. Unfortunately, too, there are no kinds of yarns or worsteds or cards—unless it be the kind used in playing whist—by which this defect in moral vision can be tested. If a director owns an interest in a furnace which makes wheel-iron, his influence may be directly exerted to have wheels made of that iron accepted. The purchasing agent may belong to that class whose only training has been in "the school of swop," and whose chief aim it is to show to the Board of Directors how little he pays for what he buys, and who, therefore, gives little or no attention to any other question excepting low-pricedness, to coin a word for the occasion. The master car-builder may be one of the kind of people "who know-it-all," and who prides himself of being practical and assumes for himself a kind of prescience, which may dispense with the adventitious aid of science or experiment and will have none of the nonsense of "them literary fellows." The wheel-maker, when wheels will not stand the prescribed test, may have friends within or without the circle of the railroad's officers, and may have impressed some of them that this testing business is all nonsense, and they bring the weight of their influence to bear against it. A lot of wheels is needed in a hurry, there is not time to test them, so they are put into service without. The testing department costs several thousand dollars a year, and the engineer in charge is paid more than some director or committeeman thinks he is worth; so his salary is reduced, and an ignorant person is put in his place—the department is badly managed and finally the whole system is swept away to "economize." In this and other ways the inspecting department falls into disrepute.

A structure of any kind, if left to itself, immediately begins to deteriorate; moth and rust are as active to-day as they were in biblical times, and decay begins when supervision ends. This is especially true of a system of inspection. The elements by which it is surrounded seem to have a destructive affinity for the material of which it is composed, and, if not constantly guarded and protected with intelligent care, decomposition will be the result.

The Master Car-Builders' Association will no doubt adopt specifications for car-wheels, but this, without inspection, will not be sufficient.

NEW PUBLICATIONS.

ANNUAL REPORT OF THE CHIEF OF THE BUREAU OF STEAM ENGINEERING, NAVY DEPARTMENT, FOR 1887. Washington; Government Printing Office.

The annual report of the Chief Engineer of the Navy contains much interesting matter, and shows that the present head of the Bureau of Steam Engineering appreciates the extent of the work to be done in this department. In times past much good work has been done by this Bureau in an experimental way, and Mr. Melville now urges a continuance of this work in the direction of the use of forced draft and high steam pressures, with triple and quadruple-expansion engines. Something has already been done in this line, and more is expected as the new ships and engines now under construction come into use.

As a necessary corollary to the advances in marine engineering already made and in progress, the report urges the advantages of still further specializing the engineer corps of the Navy and making its officers and working force still more distinct from the line. This brings up a wide question, which, it may be said, is now agitating almost every navy in the world. The modern warship is so complex a machine and so much dependent upon its engineer force, that it is no longer possible to keep that force in the very subordinate and inferior position which it occupied when steam vessels first came into use. In every country, however, the naval officers proper—the fighting men—have been reluctant to admit this, and have, as a rule, resisted all attempts to place their engineer coadjutors on an equality with themselves. It is only for the reason that the fighting ship nowadays is helpless without its engineers that they have been able to force even a partial recognition of their claims.

The report makes the excellent recommendation that engineers be attached to the staff of each flagship for inspection duty. It also urges the expediency of special details of engineers to study foreign practice and watch the improvements and experiments in marine engineering in progress in Europe.

BOOKS RECEIVED.

THE RAILROAD AS AN ELEMENT IN EDUCATION: BY PROFESSOR ALEXANDER HOGG, M. A. Louisville, Ky.; printed for the Author. This is a reprint of an address delivered before the International Congress of Educators, at the New Orleans Exposition, by Professor Hogg, who is Superintendent of Public Schools at Fort Worth, Texas.

THE STEAM ENGINE CATECHISM: BY ROBERT GRIMSHAW, M. E. New York; John Wiley & Sons (Price $1.00).

NATURAL LAW IN THE BUSINESS WORLD: BY HENRY WOOD. Boston; Lee & Shepard, and New York; Charles T. Dillingham.

JOY'S VALVE GEAR. London; issued by David Joy. This little pamphlet is mainly composed of a list of steamships, stationary engines and locomotives to which Joy's valve gear has been applied.

CANADA. STATISTICAL ABSTRACT AND RECORD FOR THE YEAR 1886: COMPILED BY SIDNEY C. D. ROPER. Ottawa, Canada; published by the Department of Agriculture. This is a valuable abstract of statistical information—geographical, agricultural, commercial, historical, etc.—concerning the Dominion of Canada.

NEWTON MACHINE TOOL WORKS: CATALOGUE. Philadelphia, 24th and Wood Streets; Charles C. Newton, Engineer and Proprietor.

The Westinghouse Brake Trials.

THE Westinghouse Brake Company has been for some time making a series of tests with a train of 50 freight cars equipped with its brake. One of these tests was made on the West Shore road at Ridgefield Park, N. J., November 21, with the following results, the train consisting of 50 cars:

	Miles per hour.	Distance, feet.	Time, seconds.
Emergency stop	22	203	12½
" "	41	674	20
" "	41	672½	20
Hand-brake stop	21	2,137	85

A "breakaway" test was then made, and the two sections of the train were stopped when 43 ft. apart.

The following test was made with a train of 20 empty cars, fitted with the freight brake, but with increased leverage for passenger service: Emergency stop at 22 miles an hour; made in 91 ft. and 6 seconds.

Another test was made with the same train and a train of West Shore passenger cars, running on parallel tracks, the brake being applied to both trains when the engines were abreast and running at the same speed:

	Speed, miles.	Distance, feet.	Time, seconds.
Freight	45	495	13½
Passenger	45	1,204	27

The tests have excited much interest, and the one in question was witnessed by a large number of railroad men.

The Pennsylvania Railroad Company's Specifications for Cast-Iron Car-Wheels and Car-Wheel Iron.

GRADING PIG-IRON FOR CAR-WHEELS BY CHILL TESTS MADE AT THE FURNACE.

THE chill cup (one of which we furnish) is to be filled *even full* at about the middle of every cast from the furnace by using a small ladle, or by placing the cup in the pig bed, a little below the level of the pigs, and letting the iron flow into it until it is *even full*. The test piece so made will be 7½ in. long, 3½ in. wide, and 1¾ in. thick, and is to be broken across the center when entirely cold. The depth of chill will be shown on the *bottom* of the test piece, and is to be measured by the *clean white portion to the point where gray specks begin to show in the white.* The grades are to be by eighths of an inch, viz.: ⅛, ¼, ⅜, ½, ⅝, ¾, ⅞, etc., until the iron is mottled; the lowest grade being ⅛ in. in depth of chill. The pigs of each cast are to be marked with the depth of chill shown by its test piece, and each grade is to be kept by itself at the furnace and in forwarding. At large anthracite and coke furnaces it is best to take three test pieces of each cast, viz.: at the beginning, middle and end, and if there is a difference of ⅛ in. or more in depth of chill between the first and last of the cast, the pigs should be divided into

two or three portions, and graded by their respective chill tests.

SPECIFICATIONS FOR 33-IN. CAST-IRON CAR-WHEELS.

DESIGN.—The design of wheels must be such that they will be in accordance with the measurements shown in the drawing accompanying these specifications, and also such that the wheels made from them shall weigh between 525 and 575 pounds each.

INSPECTION.—Wheels must all be cast in true metallic chills of the same internal diameter and uniform cross section. The treads must be smooth and practically free from "sweat," and must have clear white iron extending to a depth of not less than ¼ in. at the throat, and with a variation of not more than ¾ in. throughout the same wheel. Each wheel must be so nearly cylindrical that when a true metallic ring is placed upon the tread and bears somewhere on the cone, it shall, at no part of the circumference, stand more than $\frac{3}{32}$ in. from the wheel-tread. No wheel will be accepted whose circumference differs more than 1½ in. or less than 1 in. from the circumference of the chill in which it is made.

The body of the wheel must be composed of soft gray iron with uniform fracture and free from defects; each wheel must be capable of withstanding a pressure of 45 tons in mounting an axle.

TEST.—Representative wheels taken at random by this company's inspector will be subjected to a strength test, under a falling weight, in a machine like that shown on drawing accompanying these specifications, with an anvil block weighing 1,700 lbs. set on rubble masonry 2 ft. deep. Manufacturers furnishing wheels to this company will be required to provide one of these machines, and furnish wheels for test, as well as such facilities to the company's inspector as will enable him to test and inspect wheels promptly; they will also be required to give notice to Superintendent Motive Power when wheels are ready for inspection and test. The wheels tested will be placed flange downward and rest upon the three supports on the anvil block, and be struck central upon the hub with a weight of 140 lbs. falling 12 ft.

For each 100 wheels which pass inspection at foundry and are ready for shipment, one representative wheel shall be selected and tested as above described; should this wheel stand five blows without breaking in two or more pieces, the 100 wheels may be shipped; but should this wheel break in pieces with five blows or less, two more wheels representing the same 100 wheels shall be taken and tested, and if any two of the three wheels tested should break in pieces with less than three blows, or if the average number of blows required to break the three wheels is less than four, the 100 wheels will be rejected: otherwise they may be shipped, but the shipment in any case will be made subject to the return of such as are found, upon boring and mounting, not to conform otherwise to these specifications.

MARKS.—When wheels are manufactured under these specifications, each wheel must bear a serial number, with name of maker and date of casting.

Contributions.

The Heating of Railroad Cars.

To the Editor of the Railroad and Engineering Journal:

ASSUMING that steam from the engine will be generally used, the matter most requiring to be tested for the solution of this problem is how to supplement steam from the engine for the time when is cannot be used, before the cars are connected with it, and when it is disabled away from terminal points. Why then are the tests now being made confined to the former use (requiring only a choice between several methods to find the best), while for the latter use, nothing is done, although without providing for it the question cannot be settled?

As further proof of the necessity for extending the tests now being made, as above suggested, I add the following facts:

1. Relating to Steam from Stationary Boilers: The advantage of this method is that it answers the purpose before steam from the engine is available. Its disadvantage is that it answers no other, and in answering that, requires, in case when (as at the New York terminus of the Pennsylvania road) several trains leave at the same time, or nearly so, that the track system be reorganized; and, in all cases, that new and costly investments shall be made at all stations when trains are made up and kept always ready for use.

2. Coal stoves and heaters, the means relied on at present for supplementary heating, are not practical for that use, as they require the fuel to be removed from them in a glowing state and after short use, and therefore are too wasteful, troublesome and dangerous for use at depots. When the engine breaks down, when a stove or heater is kept in a car for that contingency alone, there would be much delay in heating it up in time, and it would be filled with burning coal when the train began to move.

3. Assuming that neither of the methods above described for heating cars before steam from the engine is available for the purpose are practical, it follows that so far as that operation is concerned, the car-heating problem is narrowed down to the enquiry, "Can gas be used for it?" In answer to which, and as proof that I appreciate the conditions required to make the use of gas on cars practical, I here state them:

The furnace used for it must burn the gas without waste, and (as heat alone and not the impact of flame must be used) must be so arranged that any undiluted heat can enter its flues, as otherwise the cost of its operation would be too great. It must not require inconvenient alteration of the car. It must be supplied by gas-pipes under the cars and connected between them, as steam pipes now are, so that when the gas used comes direct from street mains, all the furnaces in a train could be supplied from one connection with said main, turned on when the heating commenced and off when the engine came.

It must not only heat the car, but be capable of heating it quickly when required for emergencies, or in extreme cold weather. And, if possible, the heater should be so constructed that it can be changed from a gas to a coal burner or back again in a few minutes and without other change than loosening a few screws, to provide for the contingency of the engine being disabled away from terminal points, and in cases when trains are made up when there is no gas. That is the case when gas is used only for heating—when it is used for both heat and light, of course the gas in the storage tanks could be used, and the change to coal would not be needed.

Assuming that gas can be used as above stated, and the apparatus for its use so arranged that it can be taken directly from street mains while the cars are being heated up, and then shut off, so that only one heating with gas would be required for a route, however extended it may be, can any other method be safer, cheaper or more convenient? As neither storage tanks, under the cars, or special gas works would be required, except at great cities and by trunk lines, when the use of gas, if used for both heat and light, would be so great, that economy would demand its manufacture by private works.

Again, the use of mineral oils being now forbidden on cars, either gas or electricity must be used for lighting

them, whatever means are used for heating them, so that the use of gas for both purposes is really the simplest method known.

I think that what I have written gives sufficient reason to show the necessity of testing gas as well as steam without further delay.

H. Q. Hawley.

THE ENCYCLOPEDIC WORK OF THE NAVY DEPARTMENT.

By Professor R. H. Thurston.

The Bureau of Navigation of the Navy Department has during a few years past been engaged in a most important and interesting work, that of securing information of value to the officers of the Navy and to the Administration through the many sources open to it, and publishing it for distribution to the service and wherever else it is proper to send it. This work is done through a subbureau called the office of Naval Intelligence, the direction of which is entrusted to an able officer of the Navy and supervised by the Bureau of Navigation. Much of its work is revised by the Secretary of the Navy himself, and all publications are authorized by the Department and printed under its orders at the Government Printing Office in the excellent style for which that office is noted. Out of a long list of these publications a few are selected for notice.

The work of the Bureau of Navigation in this direction began many years ago, and those who have been so fortunate as to obtain the treatises issued during the administration of the late Admiral Jenkins, during and since the civil war, on the magnetism of ships and kindred subjects, have been as long aware of the excellence of the work done. Among the publications made under the direction of the Office of Naval Intelligence, having peculiar interest and which may be briefly noticed, are the report on the War between Chili and Peru in 1879–'81, by Lieutenant T. B. M. Mason, printed in 1885; the report of Lieutenant Commander C. P. Goodrich, 1882, on the Naval and Military Operations of the British Forces in Egypt, published in the same year; and the reports on Recent Naval Progress, by Lieutenant S. Schroeder, Ensign S. D. Greene, Assistant Engineer R. S. Griffin, Lieutenant W. H. Driggs, Lieutenant W. I. Chambers, Lieutenant W. H. Beehler, Ensign W. L. Rodgers and others.

The first mentioned report, that of Lieutenant Mason, is an exceedingly interesting account of the origin and conduct of the war which broke out in 1879 between the two principal South American republics on the west coast. It will be remembered that this war was a consequence of a quarrel between the two countries over the nitrate of soda deposits of the Atacama Desert, the Bolivian Government having broken treaty obligations and imposed a tax upon the nitrate business which interfered seriously with the prosperity of its managers. Peru interfering in the quarrel, and arming herself for a conflict, Chili declared war April 2, 1879. Three days later the blockade of Iquiqui was declared, and within two weeks fighting began in earnest.

Lieutenant Mason gives a very concise but satisfactory account of the resources and condition of the belligerents and of the operations of the war, both on land and at sea.

The most interesting and instructive part of the narrative is probably that in which he describes the naval contests, and especially those in which the now famous iron-clad *Huascar* took part. This ship was a "monitor" iron-clad, or turret-ship, built in 1865, for the Peruvian Government, by Laird Brothers, of Birkenhead, the firm which gained an unsavory fame during our civil war as the builders of Anglo-Confederate war vessels, and as nearly involving their own country in war with the United States by their infringement of international law. The description of the fight, on October 8, 1879, between this ship and the two iron-clads, *Admiral Cochrane* and *Blanco Encalada*, of the Chilian navy, is one of the most interesting, though horrifying, stories of naval warfare ever published, and affords a tremendous indictment of this method of settling international disputes. The result of the action was the capture of the *Huascar* by the Chilians, after the almost complete destruction of ship and crew. For about an hour and a half the Peruvian ship was under the fire of one, and, part of time, two iron-clads of greater power and much better armored than herself, and the effect of their fire was simply terrible, breaking up all of the vessel above water, destroying all her boats, and disabling turret and conning tower. The cabins and turret were crowded with the fragments of human bodies; yet the gallant men who survived fought until the enemy had actually boarded their ship and held their pistols at their heads.

The capture of the *Huascar* practically ended the contest on the sea, and the war was then fought to a close on the land. Chili had, from the first, every advantage, and gained victory after victory until Peru became prostrate before her armies, and she was able to dictate her own terms.

The report of Lieutenant-Commander Goodrich on the British naval operations in Egypt, in the summer of 1882, is a very extended account of that remarkable outcome of the modern methods of warfare, if that can be called warfare which consists in the attack of such a very powerful nation upon such a very weak one. The report also illustrates well the extent to which the amenities of modern life and civilization have been imported even into the greatest surviving relic of barbarism, the fighting of nation with nation. The information contained in this report could only have been gathered with the assistance of the British officers engaged in these operations; and Mr. Goodrich makes graceful acknowledgement of such aid.

The report is divided into three parts: An account of the causes of the outbreak of hostilities, and descriptions of the attacking and defending forces and of their naval and military material, including ships, fortifications and guns; an account of the various naval and military operations of the war; and the study of the non-combatant divisions of the service. A very interesting and exact account is given of the defenses of Alexandria, of the armored and other vessels employed by the British Government in the attack, and of the effects of the fire upon the ships and fortifications. The operations of the fleet after the bombardment of the Alexandrian forts and other operations preceding the change of base at Ramleh, the composition of the expeditionary force, and the steps taken resulting in the seizure of the Suez Canal, and the

remainder of the short but decisive campaign are fully detailed.

Perhaps as interesting a portion of the report as any, to civilian and scientific readers, is the account of the methods of operation of the railroads, the telegraph system, the post-office, the medical department and the systems of transport. A comparison of the Indian troops with the British in their methods of operation, their habits of life, and their value as soldiers and in the army organization is not the least interesting portion of this very interesting work.

It has been asserted by many who should have been trustworthy and accurate witnesses that the war upon the *de facto* Government of Egypt, initiated by the bombardment of Alexandria, July, 1882, was entirely without real cause or justification, and this was very strongly held and promulgated in many addresses, given at the time, in various parts of this country by American ex-officers of the Egyptian Government. Acording to the British accounts, and the statement is supported by Commander Goodrich, the fact is that a set of native and foreign officers had gradually "wrested the power from the hands of the Khedive, their legitimate ruler, and had wielded it in such a manner as to paralyse trade, destroy confidence, and cause the foreign population to desert the country by thousands." The concentration of the British naval forces in the harbor of Alexandria only stimulated the feeling against foreigners already threatening the destruction of all such citizens; and the strengthening of the fortifications, which was caried on under the very guns of the British fleet, in spite of protests, indicated an intention of resorting to violence should the relations between the native and the British parties become more strained. It was thought best by the British commander to send to the Government of Egypt an *ultimatum*, threatening to attack the forts in the harbor should the mounting of guns not be at once discontinued and those in process of installation removed. This demand was not acceded to, and the result was the initiation of a campaign, the general outcome of which is well known to every intelligent reader of the daily press.

We cannot attempt the formal review of so extensive a document, and must be content with the briefest possible notice, and a few extracts illustrating the extent and value of the mass of information collated by Commander Goodrich. The report is well illustrated by engravings exhibiting the character and general construction of the British iron-clads engaged at Alexandria, the extent and disposition of the forts, and the nature of the apparatus and material employed. Good photo-gravures of the exterior and interior of the forts after the bombardment exhibit well the effect of the shot thrown from the heavy guns of the vessels of war, and maps and plans are introduced wherever they can be made useful. Thus the bombardment of Alexandria, an event having very little significance in itself, perhaps, and having none of that peculiar interest which attaches to bloody engagements and well-fought fields, is made a means of instruction in the arts of naval and military engineering, such as seldom if ever had been previously obtainable. Some of the conclusions derived from the study of this bit of war are the following: The height of a fort above the sea level is a matter of the greatest importance, a slight rise giving, often, great advantages. This was well shown during our own civil war by the misfortunes of the *Galena* and her sister ships on the occasion of their attack upon the forts on the high bluffs on the James River. The vessels were seriously damaged, while the forts were uninjured.

At Alexandria, a difference of 14 ft. in the altitudes of the Lighthouse Fort and Fort Pharos gave the latter an enormous advantage, and it suffered comparatively little, while the former was badly cut up and its guns very generally dismounted. It was found, also, that no projectile mounted in the British fleet was capable of sending a shot through 30 ft. of earthwork, though some of these guns were of 81 tons weight, and it is even doubted whether the 100-ton gun with its 40,000 foot-tons of stored energy could drive a shot through that thickness of earth. Lines of fortifications should be, wherever possible, unbroken, and the guns should be of the same color as the masonry in order that the gunners attacking them should not be furnished with a target at which to aim with exactness. Low-powered guns of high trajectory are considered best for the attack of earthworks. High-powered guns, with their low trajectory, drive their shot in at the limit of maximum resistance. Ships should, on such occasions, have composite batteries. Perhaps the most important of all lessons taught by this incident of war are that vessels are not and cannot be expected to be able to fight on even terms with forts or shore batteries, and that, on the other hand, the latter are utterly powerless to stop the progress of any well-handled and satisfactorily-armored fleet of the present day. The fleet may pass on without so much as noticing the fort and with almost perfect impunity. The art of defense has so far outstripped that of offense that each system, as constructed to-day, is practically unconquerable by the other. The same fact was well illustrated in our own last contest by the permanence of the defenses of Charleston and by the passage of the forts at New Orleans by Farragut's fleet. The fact that the latter was a wooden fleet emphasizes the advantage possessed by the warship in its mobility.

Among the miscellaneous conclusions which attract attention in the midst of the encyclopedic mass of information here given us, is that which Lieutenant Greeley also reached after his experiences in the Arctic regions: that "grog" was not only useless, but that the troops were better without it. Accordingly the ration issued ordinarily was changed, increasing the allowance of tea, adding lime-juice, substituting potatoes and rice for fresh vegetables when they were obtainable, and abolishing the daily "tots" of rum. It is interesting to read that "great dissatisfaction was felt on the part of the British officers with the lack of a means of summary punishment to take the place of flogging" now abolished, a feeling also expressed on somewhat different grounds by many citizens of Chicago since the trial of the anarchist murderers in that city. It is stated, in referring to the use of the filthy waters of the "Sweetwater" Canal, that they did not, so far as could be observed, produce disease. Diarrhœas were caused by the heat and exposure of the campaign, even where the men were given distilled waters. "Heat apoplexy was probably the only true climatic disease." Antiseptic surgery was employed from the first, and with good results, carbolic acid being the antiseptic commonly employed. Mercuric chloride, the favorite antiseptic among our own surgeons, does not seem to have been generally used. Hospital accommodations and the hospital service generally were not always of the best, although

in some cases the refinement of charity went so far as to provide *iced champagne* among the medical stores actually issued.

One of the last of the many recommendations of this instructive report is one which will appeal strongly to every executive officer in our colleges as well as in other administrative positions:

"The practice of mentioning juniors in despatches . . . is one of the most marked features of all the official reports . . . The sense of duty well done may be all that an officer has a right to expect; but, until human nature changes entirely, even the most conscientious person will not fail to find a stimulus to still greater exertions in the field, or more prolonged and earnest labors in the cabinet, in the thought that his efforts, if successful, will become part of the annals of the service to which he devoted his life without reserve."

The last of this series of publications which we have occasion to notice is that on Recent Naval Progress, published by the Navy Department in June, 1887. It makes a volume of about 350 pages and is full of important and interesting information relating, mainly, to purely naval matters. Perhaps the most important paper of the collection is that with which the volume opens, a contribution by Lieutenant Schroeder on the Development of Modern Torpedoes, which is supplemented by an appendix, describing experiments at various British and other European ports. The introduction of the torpedo into warfare is a recent event, notwithstanding the fact that the invention originated at a comparatively early date. Bushnell's floating torpedoes of a century and more ago, and their use in the War of the Revolution, are well-known historical events; while the rhymes describing the "Battle of the Kegs" have taken a permanent place in our literature.

It is also a fact familiar to every student of history that Robert Fulton, a little later, made some effort to work that promising field of invention, and succeeded in producing effective torpedoes, and in operating them by means of a submerged vessel impelled by a screw which was probably the best submarine boat ever constructed up to the date of our own civil war. It is not surprising that this should have always been a most attractive department of work for ingenious mechanics.

No one can fail to recognize the fact that it is to such developments as we are now witnessing that we are to look for that final outcome of military and naval progress which is yet to make war between civilized nations impossible in consequence of the very efficiency of their implements and machinery of destruction. When the torpedo system has become to such an extent perfected that no fleet can with safety approach the shores of an enemy, and that the most powerful iron-clads and rams will certainly be destroyed whenever they come into the presence of a fleet of torpedo-boats, the whole cost of that fleet being less than that of a single first-rate armored vessel, naval wars, at least, will cease, and disputes among nations will be brought much nearer to adjustment by discussion and arbitrament, and will be settled, if worst comes to worst, by the proclamation of non-intercourse, the penalties of which in the interruption of internal business and inter-state trade will be amply sufficient to bring about a settlement. The perfection of the torpedo, in its several forms of fixed, floating, movable and automatic apparatus, will be thus seen to be a matter which must be of vital importance to every nation, and especially to one which, like the United States, is disposed to rely upon the more decent and civilized methods of preservation of the peace. Not only is the torpedo the only reliance of our country in case of a war with a foreign nation, but it is that form of instrument of warfare which is most likely to put an early end to all naval contests. The torpedo also has a place in army operations; but there it is of vastly less importance. The perfection of ordnance, small and large, insuring the destruction of any force that may be exposed to fire is what we must rely upon to insure a similar issue on land.

Lieutenant Schroeder's report report gives a very full account of all the approved forms of torpedo, from the towing apparatus and torpedo of Harvey to the automatic torpedo of Whitehead and that of Lay. The projectile torpedoes, among which is the Ericsson, as fitted to the *Destroyer*, are not the least interesting of the numerous forms of this weapon. It is a form which Fulton and many later inventors had great faith in, and it is expected that it will in time prove useful, Rocket torpedoes for naval purposes are not considered promising. The fish torpedo, as that of Whitehead, in which the power is stored in the instrument itself, and which is, in the case of Lay's invention, capable of being guided from the vessel or the shore, as an instrument of aggression is of the highest rank. It is a singular fact that the device of Whitehead is not held by patents but by the retention or sale of the secrets of the inventor. These torpedoes are now made up to 20 ft. in length, attaining speeds of 27 miles an hour, using air compressed to a pressure of 1,500 lbs. per square inch and carrying a detonating charge of 100 lbs. of gun-cotton. Howell's torpedo is an ingenious and effective application of the principle of transformation of energy. Commander Howell uses a fly-wheel which is driven up to an enormously high speed—10,000 revolutions a minute—and thus stores power which is later applied in the propulsion of the screw of the torpedo. It is wonderfully simple in design and construction and is reported to be very promising in its performance.

The Lay torpedo differs from the preceeding forms in the very extraordinary fact that it is controllable from the ship or from the shore while in motion. Many modifications of this general plan by various inventors have been tried, some of them with promise of success when experience shall have given the clue to the methods of perfecting them in details. Liqueified carbonic acid is the working fluid for its engines, and both engines and rudder are controlled by an electric current through cables trailing behind the torpedo as it shoots ahead at the rate of, sometimes, over 20 miles an hour carrying a charge of 200 lbs. of dynamite against the enemy with a certainty of his destruction which is not approached by any other instrument of the class. As improved by Patrick this is the most formidable of all recent "peace-compellers."

The other papers in this valuable collection are, in many cases, as important and as exhaustive as that just reviewed and the volume, as a whole, has very great value, not only to the naval officer, but to the engineer in civil life, and to many others interested in applied science.

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

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CHAPTER II.

RECONNOISSANCE.

As we have before stated, a man to excel in location must have a natural talent for it. It must be born in him—something never to be acquired. So now let us say that it is in reconnoissance that this born locator has the best chance to exhibit his talent. Anyone with proper instruction can do the surveying needed on location when he is told what to do; he can run any line when the line is pointed out to him; but it needs the man with the natural talent, improved by study and practice, to point out the best line for a railroad in any kind of country.

In every way the reconnoissance is the most important part of the conduct of a railroad location, and under no circumstances should this work be delegated to an assistant.

This reconnoissance of a country which precedes a railroad survey is an examination, made with extreme care, of that section of the country through which the railroad may pass, or at least all that part of the country that lies between the terminal points which have been decided upon previously. The object of this reconnoissance is to find, by means of the eye, principally, where the best line for the railroad lies between the terminal points. The engineer must have a perfect understanding as to the kind of railroad he wishes to locate, in regard to the amount of probable traffic, the class of traffic, and all the other points mentioned in Chapter I.

By the best line, the engineer must remember that the one with the least work in construction is not necessarily meant; neither must all his endeavors be toward the shortest line. But the best line, as has been said before, is where the minimum of both construction and operation expenses meet.

There is one idea which the young engineer should have firmly impressed on his mind, and that is, that, no matter in what country he is, there is somewhere a good line for a railroad between any two points. By a good line we mean one that is eminently better than any other. Also, let him always have the idea that this best line is not the one he thinks it is at first, but one that can only be found after careful examination. In this examination the object must be to get a good general idea of the topography of the belt of country to be examined; to get the position, direction and size of all the water courses; the position and relative height of all the controlling points, such as the different passes through the hills or mountains, water-sheds, etc.; the position of small intermediate villages, that is, such villages as are not of enough importance in themselves to make it advisable to spend much money in building the railroad to them, if a better line, both in construction and operation, can be found by leaving them to one side. In fact, the object of this examination is to get a perfect idea of the country without taking up too much time.

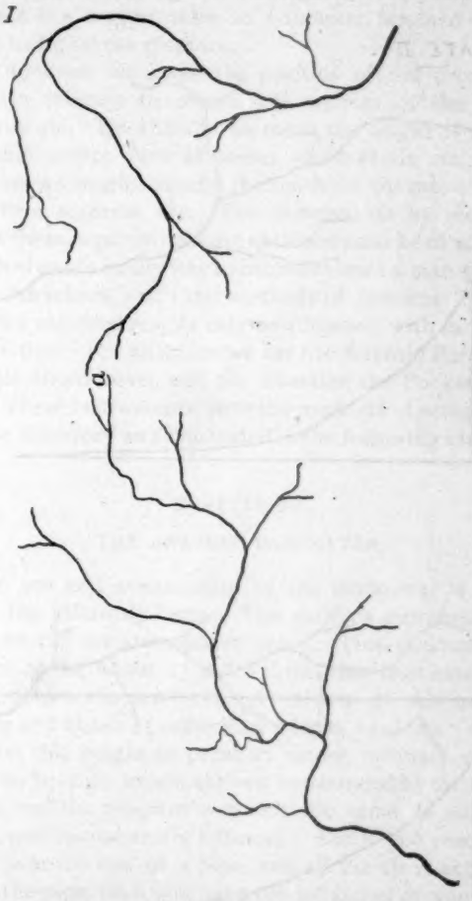
The manner of accomplishing this object is as follows:

The engineer in charge of reconnoissance should get the very best maps of the country that can be procured. In most cases, these will be anything but satisfactory; still, a very good idea can be obtained of the more prominent topographical features. These maps should be studied with great care, until the required section of country is memorized, and a complete plan made of the manner in which the reconnoissance in the field is to be conducted. Notes in sufficient quantity should be taken, so as not to burden the memory of the engineer in any way more than is necessary.

When he has notes of all the principal points that he wishes to visit and examine, let him find out all the best ways of getting there, and make all his arrangements so as to lose as little time and cover as much ground in the field as possible.

In studying the maps before going into the field, and

PLATE I



afterwards in examining the ground, let the engineer remember the following points:

The position and direction of the water-courses will give him always the lowest land, and, if the proposed railroad crosses a divide between two water-sheds, the water-courses will mark the position of this divide and also the different passes through it.

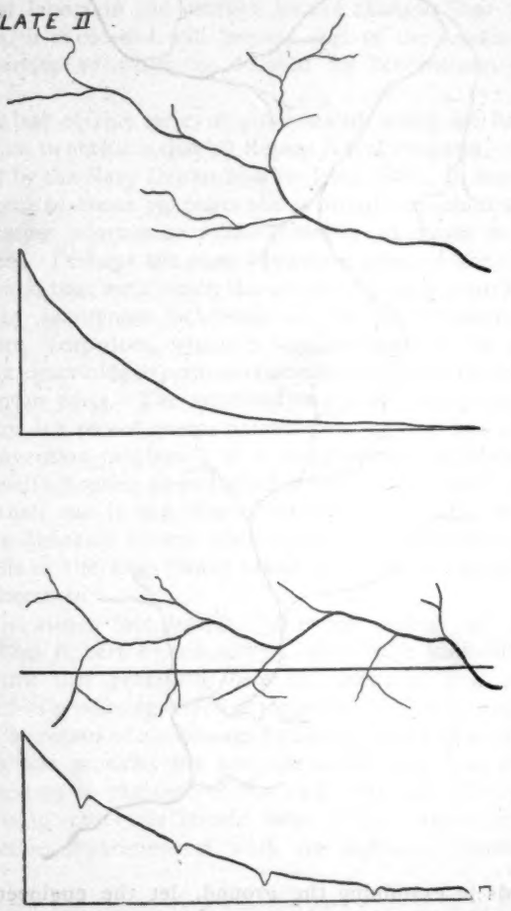
The rate of fall of the water-courses gives the grade of any railroad built along their banks, and this grade will always be found to be steeper near the source of the river, and to gradually grow less as the distance from the source grows greater. Where the course of a stream is comparatively straight, the rate of fall is usually much greater than where it winds and turns a great deal. Any line which follows the course of a river must cross all its tributaries, and thus often necessitates deep fills and many bridges.

Any line which runs along a steep hill-side is in danger

of slides and wash-outs, but in construction side-hill work, that is, where part of the work is in cut and part in fill, is much cheaper than a through cut or fill, as the material that must be excavated to make the cutting is used to form the fill, without any of the expense of cartage. When the hill-side is of rock, there is very little danger of slides, and there is a very great difference in the cost of construction, as it is a very great expense to remove the rock from a through cut, even after it has been broken up by blasting; while, in the case of a side-hill, by a judicious use of the drill and explosive material, the bulk of the material is at once thrown out of the way by the explosion, and the remainder can be rolled down the hill at slight expense. (See Plate III.)

When the young engineer first goes into the field on

PLATE II



location, he must not feel any doubt as to the success of his work if the country is very much broken and mountainous, for the reason that an exceedingly rough country is often much easier to locate through than a more level one. The reason of this is that in a rough, broken country there is less left to the judgment of the engineer. The topographical features are very decided. Nature has often located the line and almost staked it out, and as the engineer has simply to follow the line so plainly held up to view, there is very little chance of his going wrong.

On the other hand, in a more regular, even country Nature has not shown in such a definite manner which is the best line, and the engineer has more work to do in order to find among the many possible lines which is the best; and the greater call there is upon human judgment the greater chance there is for error.

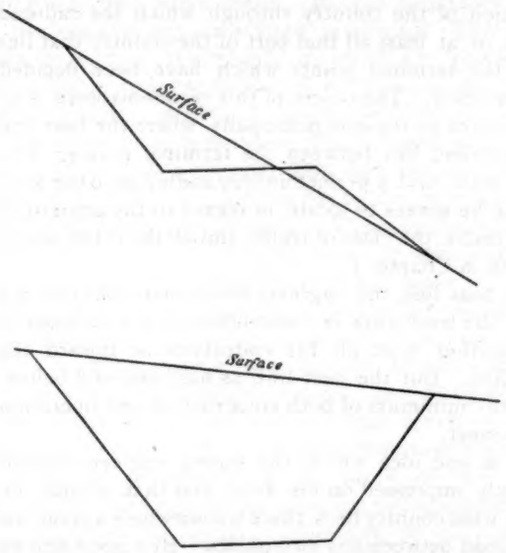
An illustration of the different profiles that can be obtained by different lines running between the same terminal lines is given in Plate IV.

All the different lines shown run from *A* to *B*, and the line which gives the smoothest profile is the line *c*, which keeps nearest the sources of the river; it is also the longest line.

In work in the field, the young engineer must take much care that he does not judge of the difficulties of building the railroad to a certain extent by the difficulties he has in getting over the ground. Often, on ground where it is almost impossible for the engineer to pass at the time of the reconnoissance the lightest work in construction will be found. In the same way, the reconnoitering engineer must not confine himself to highways and the open country. This is always a temptation, and the location of parts of many railroads has been ruined by it.

In making a reconnoissance, it should be made on horseback or on foot, and the engineer should have with him, as guides, one or more of the inhabitants of the coun-

PLATE III



try who know all the short cuts, passes, rivers, streams etc.

Now, in examining the ground, the work should be done slowly and carefully, the engineer taking copious notes and sketches. When he has finished, he must be so familiar with the whole country that he can at any time call up a mental picture of it, with its mountains, rivers and other topographical features, so that he can at once see mentally the obstacles that would be encountered by any line running between the terminal points.

One point that should be studied by all engineers is, to be able to look at a piece of country and make a reasonably exact guess as to the cost per mile of constructing a railroad across it. This can only be acquired by long practice. The only persons we have who are in any way expert at such estimating, are old railroad contractors, who, from their long experience, can guess with most wonderful exactness at the number of cubic yards to the mile that any country will run.

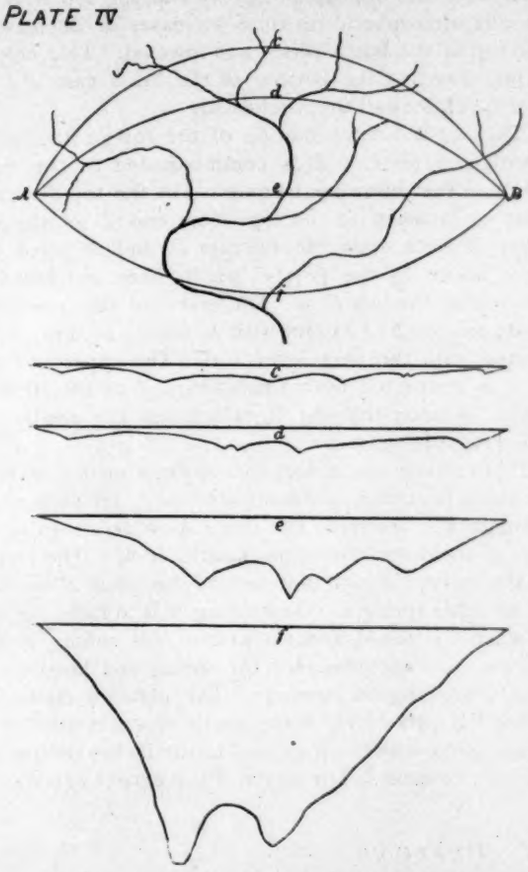
Another thing to be guarded against in the field is optical delusion. In most situations it is almost impos-

sible to judge, with any degree of exactness, of altitudes, or even whether the ground is inclined up or down hill, by the eye alone. When one looks at a hill or mountain, it always has the appearance of being much steeper than it really is; rivers and streams appear to fall much faster than they really do.

Let the engineer by practice find out what his "personal equation" is and then regulate his estimates by it.

With a good reconnoitering engineer, one of the class we spoke of in the beginning, who has natural talent and plenty of practice, and who has given him what time he needs on the reconnoissance, the work of surveying will be very much decreased. In most cases it will be necessary to run only one through line; of course, many of the details of this line will have to be run and re-run, but with proper attention to the reconnoissance, the general line and the grades

PLATE IV



that can be used can be decided upon, once for all. Of course, it takes a thoroughly competent engineer to do this, and the majority of our engineers put upon location are not competent on this point. This is not so much the fault of the engineers as it is of the railroad companies. Until within the last few years they would not pay properly for a locating engineer, and naturally could not get first-rate men for third-rate pay. The engineer hurried through his work on location as rapidly as possible, and with as little work as possible, and jumped at the first chance on construction that offered as a situation where he would get fair pay for fair work.

One great trouble our engineers have is that, as soon as a company has decided to build a railroad, its managers are so anxious to commence the work of actual construction that they allow very little time for reconnoissance, and consequently the work is only half done. The company has to pay for this neglect when the road comes to be operated.

In speaking above as to the class of engineers who go on location, the author wishes to say that he has met with many honorable exceptions, men who had done everything to improve a great natural talent for locating and reconnoitering, and who had arrived very near perfection.

In this work of reconnoissance, the three elements which the engineer wishes to find quickly and with approximate accuracy are distance, direction and altitude. The distance passed over can be taken with sufficient accuracy by means of the time occupied in passing from point to point. Very little practice will show the engineer at what rate he moves either on foot or horseback and if the journey can be made in a wagon, then an odometer fastened to the wheel will give the distance.

By direction we mean the position of one prominent point in relation to others, the courses of the rivers, streams, etc. By altitude we mean the height of all the desirable points, such as passes, water-sheds, etc., above some known height, usually the sea-level, the rate of fall of the rivers, streams, etc. The instruments by means of which these required data are obtained must be of such size and form as not in any way to inconvenience a man walking or on horseback, and their methods of use must be such that the required results may be obtained with minimum loss of time. For altitudes we use the Aneroid Barometer and the Hand-Level, and for direction the Pocket-Compass. These instruments, with the methods of using them, will be described and illustrated in the following chapters.

CHAPTER III.

THE ANEROID BAROMETER.

The use and construction of the barometer is based upon the following facts: The earth is surrounded by what we call the atmosphere or air. This atmosphere is known to be about 45 miles thick, that is, it extends 45 miles above the sea-level. A column of this air 1 in. square and about 45 miles long weighs 14¾ lbs. We do not feel this weight or pressure under ordinary circumstances, because we are entirely surrounded by the atmosphere, and the pressure is exactly the same in all directions, and consequently balances. But if you place your hand over the end of a pipe, and all the air is exhausted from the pipe, then you have the sensation of your hand being sucked into the pipe. This is merely the pressure or weight of the atmosphere acting on the other side of your hand, and you are sensible of this weight, because the counter-weight or pressure on the other side has been removed.

The air is much more dense at the sea-level than at some distance above it, owing to the greater weight from above pressing it down. Therefore, the higher you get above the sea-level, the less is the weight of the atmosphere, owing to the fact that the column itself is shorter and that the atmosphere is less dense.

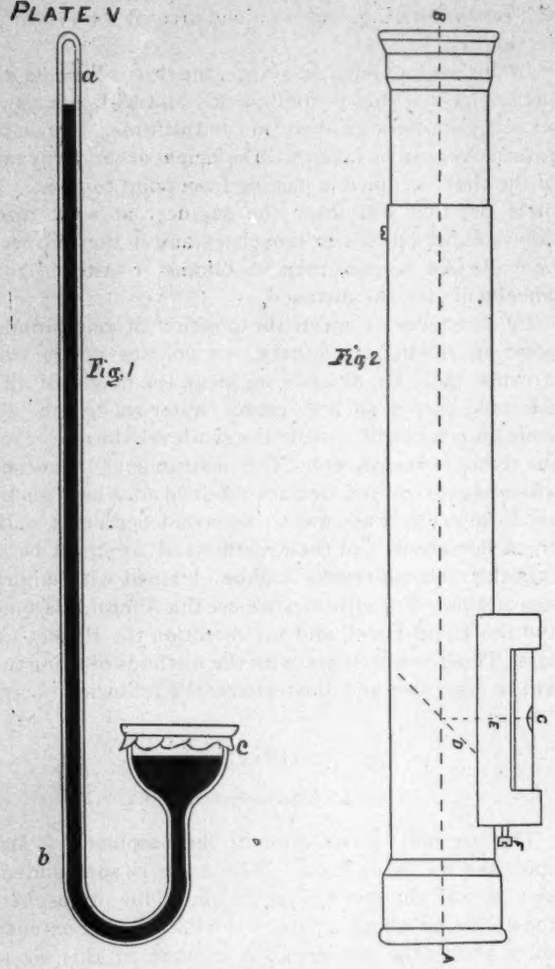
It is upon this fact, that as you rise above the sea-level the weight or pressure of the atmosphere becomes less, that the use and construction of the barometer for obtaining altitudes is based.

The cistern, or mercurial barometer, Plate V, fig. 1, consists of a graduated glass tube, *a b*, with a bulb or cistern, *c*, at the bottom. The air is all exhausted from the tube,

and it and the cistern are partly filled with mercury. The top of the cistern *c* is then covered with some air-proof elastic substance, such as rubber.

The air having been exhausted from the tube, the

PLATE V



weight of the air at *c* forces the mercury up in the tube, until the weight of this column of mercury just equals, or balances, the weight or pressure of the atmosphere.

At the sea-level, when the atmosphere weighs 14¾ lbs., the column of mercury will stand just 30 in. high in the tube. As we rise above the sea-level the pressure of the air grows less, and the column of mercury falls. In round numbers the mercury falls 1 in. for each 1,000 ft. we rise; so that, knowing this, we can tell approximately how high above the sea we are by the height of the mercury in the tube.

The mercurial barometer, with its glass tube over 30 in. long, is a most inconvenient and delicate thing to carry. The barometer used, therefore, for taking heights in the field, is what is called the aneroid barometer. The principle upon which it works is exactly the same as the mercurial barometer, namely, the decrease in atmospheric pressure as we ascend.

Plate VI represents a section of an aneroid barometer, showing the interior mechanism. Plate VII is a perspective view of the same. *A* is a small metal box, the top of which *B B* is corrugated, as shown in the figure, to give it greater elasticity. This box *A* is air-tight, and all the air is exhausted from the inside. Then, of course, the weight of the atmosphere presses in the top *B B* and, as this atmospheric pressure increases or decreases, so the top of the box is raised and lowered. This box *A* is firmly fixed to the bottom of the brass case *P P P P*, which contains all the mechanism.

This up-and-down motion of the top of the box or corrugated plate *B B* is communicated to the needle *M M* in the following manner: On the top *B B* is the post *C*, fastened to the top. One end *T* of the main lever *D* rests upon the fulcrum *O*, and is acted upon from above by the post *C*, which rises and falls with the top of the box *B B*. The end *S* of this main lever *D* is connected by a joint with *E*, which, in turn, is connected with the bent lever *F G*. The upper end *V* of *F G* is connected by a small chain, *J*, to the drum *K*, which is upon the post *W*, which has the needle *M M* upon its upper end.

From this, it can be seen that any motion of *C*, either up or down, is at once communicated to *D*, and from thence through the levers to the drum *K* which, turning one way or the other, moves the needle *M M*. The chain *J* is always kept wound taut around the drum *K* by means of the little spring *L*. The spring *N* is to raise the lever *D* when *C* is raised, and the weight *H* is simply, in some degree, to counterbalance the spring and keep all the levers working on bearings. The plate or circle *X X*, Plate VIII, above which the needle moves, is divided into equal parts which correspond to the inches on the mercurial barometer. The length of these parts, of course, depends upon the diameter of the circle. In a 5-in. barometer the needle is 3 in. long, and the diameter of the circle is the same. In this case, the length which corresponds to 1 in. of the mercurial barometer is about 1½ in. That is, the point of the needle will swing over 1½ in. of arc

PLATE VI

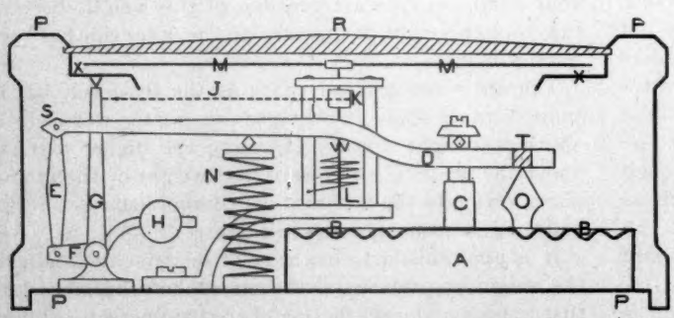
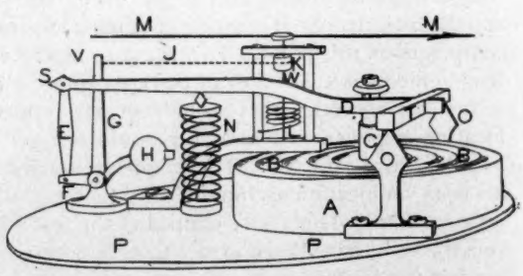


PLATE VII

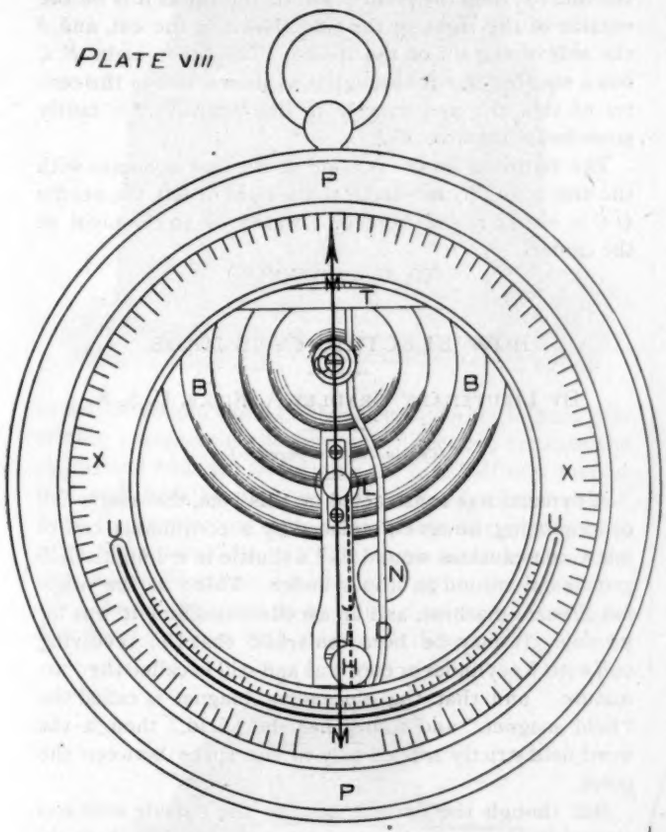


for the same change of atmospheric pressure that would move the mercury up or down 1 in. in the mercurial barometer; and this corresponds to about 1,000 ft. change in elevation of the instrument.

Thus this 1½ in. on the divided circle, which is called an inch, corresponds in round numbers to a difference of elevation of 1,000 ft.

This inch is divided into 10 equal parts, each representing 100 ft., and these again into 10 parts, each equal to 10 ft. These smaller divisions can easily be again divided in half by the eye, so that elevations can be read to less than 5 ft.

The most exact method of using the barometer in determining heights, is to work from some point of known elevation, either back to the same point or to some other point of known elevation, as these given points will act



as a check upon the results given by the readings of the barometer.

Before commencing work the aneroid barometer should always be compared with some standard mercurial or aneroid barometer, and any difference in the readings noted; and after the readings at the various points have been taken, the correction should be applied. This is a much better method than attempting to correct the error in the instrument itself by means of the adjusting screw, which is attached to most instruments. The aneroid being a delicate piece of mechanism, it is better to use the correction for a known error, than to take the chances of getting in an unknown error by changing the adjustment.

Although most of the aneroids claim to be compensated for any changes of temperature, still in all work the temperature should be taken with each reading and the proper correction made in working out the heights.

While in use, the aneroid should be held in a horizontal position and allowed to remain in that position a sufficient length of time to permit it to feel the full effects of the changes in the atmospheric pressure. Just before the reading is to be taken, the aneroid should be gently tapped with the finger in order to do away with any sticking of the needle or any part of the mechanism. On any important point, as many readings as possible should be taken, and those results which were taken under the most similar circumstances, should be be averaged.

In using the aneroid on reconnoissance, the object is not so much to get the actual height of the various points above sea-levels, as to find their relative heights; that is, how much higher or lower one point is than another, and this can be done very correctly by the following rule, much care being used when taking the readings:

RULE.

As the sum of the two readings is to their difference, so is 55,000 to the difference in elevation between the two points.

Example:

First reading, 28 in.
Second reading, 27 in.
$27 + 28 = 55$
$28 - 27 = 1$
$55 : 1 :: 55{,}000 : 1{,}000$

the difference in elevation between the two points.

Much care must be taken in the use of the aneroid, as without this care most serious errors will be made and the value of the work lost.

With care and practice, however, results may be obtained of sufficient accuracy to answer every purpose of a reconnoissance. The best aneroids cost from $35 to $50. The mechanism, by means of which the rise and fall of the corrugated top *B B* is made visible to the eye and is measured, differs to some extent in the instruments of the different makers, but the principle is the same in all. Every first-class aneroid has a thermometer, *U U*, Plate VIII, attached to it with which to take the temperature.

Plate VIII is an outside view of an aneroid barometer, showing the face of the instrument.

There are many small, cheap aneroids made and sold to tourists, but they are generally too unreliable for any engineering work.

CHAPTER IV.

THE HAND-LEVEL AND POCKET COMPASS.

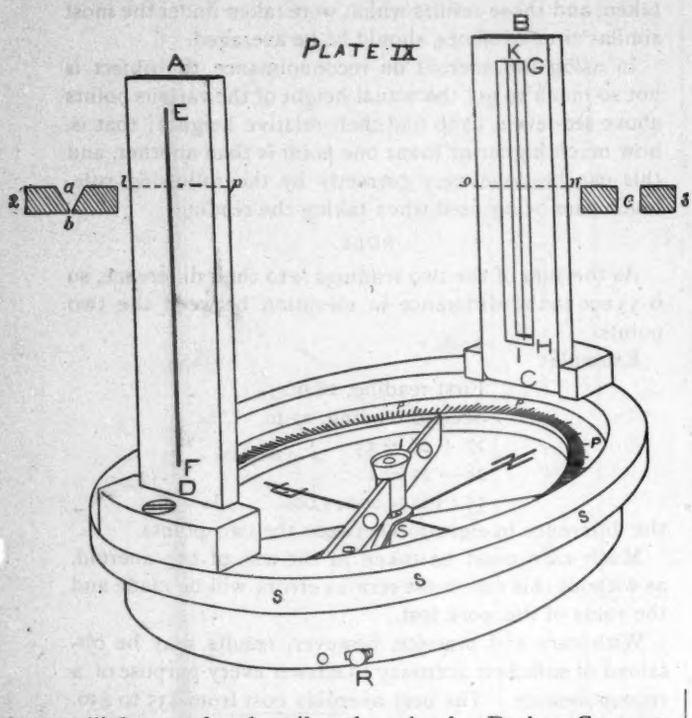
The LOCKE HAND-LEVEL is shown in Plate V, fig. 2. By simply holding this instrument in the hand and looking through it one can tell approximately all the objects that are on a level with his eyes. In this plate, *A* is the eye end of the level and *B* the open end. *C* is a small bubble enclosed in a brass box which has an opening in the top and one in the bottom. *E* is a vertical wire which runs down from the center of the bubble tube, and is set in a small plate so that it can be moved back and forth by means of the screw. *D* is a semicircular mirror, which occupies one-half the tube and is set at angle of 45°.

The only adjustment of the instrument possible is that of the wire *E*. To adjust this, place the instrument in a perfectly horizontal position, and then if, in looking through it, the wire does not cut the bubble in the center, move it back and forth by the screw *F* until it reaches the proper position.

The POCKET COMPASS, of which we give a perspective view and plan (Plates IX and X), is used to obtain approximately the direction of one prominent point from

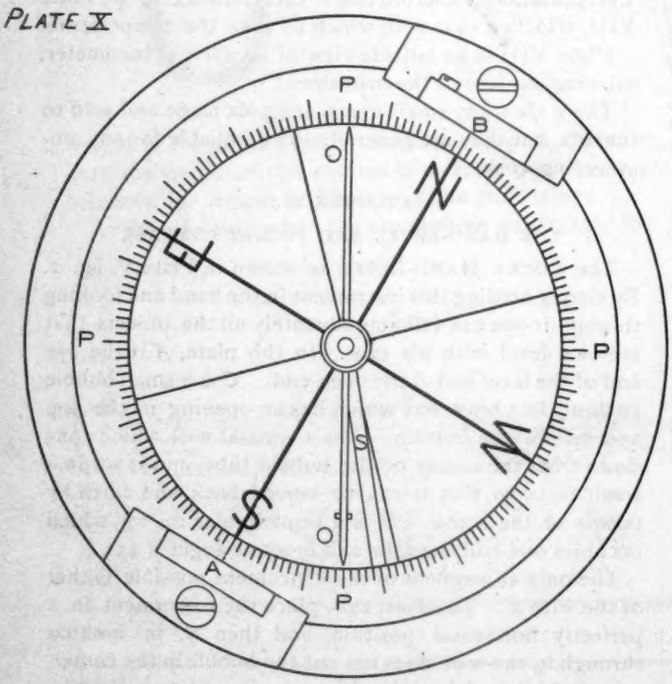
another, the general direction of the water courses, etc. The principle upon which its use is based is simply that of any magnetic compass, that the needle *O O* will always point north and south when the instrument is held in a position nearly enough level for it to swing freely. We

PLATE IX



will here only describe the simple Pocket Compass with folding sights, because, while there are many other instruments of modern invention which have, to some extent, superseded the use of this upon reconnoissance, their

PLATE X



mechanism and manner of use are more complicated, the principle being still exactly the same.

The ordinary pocket compass, which is shown in perspective in Plate IX, Plate X being a face-view, consists of a brass case, *s s s s*, anywhere from 2 to 5 in. in diameter. On the inside of the case, which is covered with glass, there is a plate, *P P P P*, which is divided into degrees or half-degrees, as represented. Then the four cardinal points *N*, *S*, *E* and *W* are marked on the plate. The magnetic needle *O O* swings freely on a pivot in the center and always points north and south. On the outside of the case and directly in line with the north and south line marked *N* and *S*, Plate X, are two sights *A* and *B*. These sights are pieces of metal a little shorter than the diameter of the case and work on the hinges *C* and *D*, so that they can be shut down over the glass top of the case when the compass is in the box. The sight *A D* has an extremely narrow slit, *E F*, cut in it exactly on the line *N S*. The shape of this slit is shown in section separately. Let *a b* represent a horizontal section through the sight *A D* on the line *l p*, then the point *a* will be the slit as it is on the outside of the sight or the side shown in the cut, and *b* the side of the slit on the inside. The other sight *B C* has a square slit, cut through it as shown, and in the center of this slit and exactly in line with *N S* is tautly stretched a fine wire, *K I*.

The button *R* on the outside of the case connects with the arm *S*, and by moving *R* to the right or left, the needle *O O* is either raised from or lowered on to the pivot at the center.

(TO BE CONTINUED.)

HOW ELECTRICITY IS MADE.

By Lieutenant Bradley A. Fiske, U. S. N.

(*Concluded from page 505.*)

A dynamo was constructed on this plan, the single coil or loop being, however, replaced by a continuous coil of many convolutions wound like a shuttle in a longitudinal groove cut around an iron cylinder. This was the original *Siemens* machine, and an excellent machine it was for its day. It may be here remarked that the revolving coil with its cylinder or core was and still is called the "armature," and that the embracing magnet is called the "field magnet," and sometimes the "field," though the word field strictly applies only to the space between the poles.

But though the current sent to the outside wire was always in the same direction, it is plain that it could not be strictly continuous, because it fell to zero twice during each revolution at the times when the current in the armature changed in direction; and it was by reason of overcoming this defect that the invention of the Gramme machine (or "dynamo," as it is usually called) in 1870 caused such an enormous advance all over the world in the generating of electricity upon a large scale. This machine is shown in fig. 11.

Gramme replaced the single coil of wire, with its ends connected to two brass segments on its axle, by a number of separate coils wound on the circumference of a ring, as shown in fig. 11 *a*, the ring being revolved also between the poles of a magnet N and S, the ends of the coils being connected to each other in such a way as to form a continuous circuit all around the ring and also connected to the various brass strips shown, which were secured separately to the axle. As in the old Siemens machine, two brass brushes to which the ends of the outside wire were attached pressed on these strips in succession, as

the ring or armature revolved. A little consideration will show that each one of the coils in a Gramme machine, in rotating, acts exactly like the single coil already described; and, as the coils are connected together, all of the coils which are on the right side at any instant generate currents

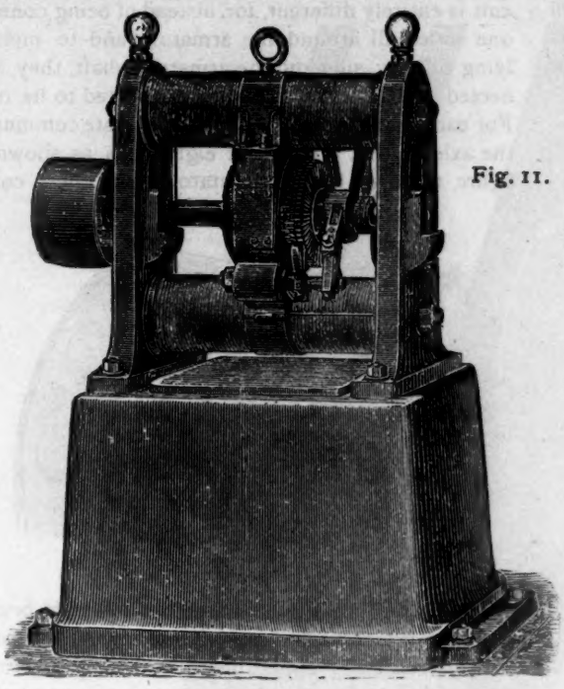


Fig. 11.

in one direction, while all those on the other side are generating currents in the opposite direction, because the right-hand coils are performing the first half of a revolution, and the left-hand coils are performing the latter half. Now, if the currents were in the same direction in both sides there would be one continuous current around the ring, flowing down on one side and up on the other, but since the currents are in opposite directions, they must flow up or down on both sides, and, therefore, join forces

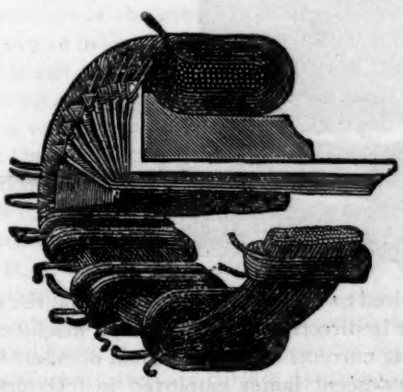


Fig. 11*a*.

at the upper or the lower brush. If, for instance, the coils are so wound that the current flows up in the coils on both sides, both currents will unite at the upper brush, where they will pass together into the outside wire or circuit, and thence through the outside circuit and back to the lower brush.

The very important fact will be observed that so long as the armature revolves, the current in the external circuit will never fall to zero as it did in the old Siemens machine, for the reason that though the current in each individual coil falls to zero twice in a revolution, yet the external current is the aggregate of all the currents produced by the coils, so that at the very instant when the current in one coil on each side is reduced to zero by reason of changing direction, there are other coils generating a strong current, so that the total current in the external circuit is merely reduced the proportional part due to one pair of coils. Therefore, the external current, though not perfectly continuous like that from a voltaic cell, has only a slight undulatory character very different from the throbbing Siemens current.

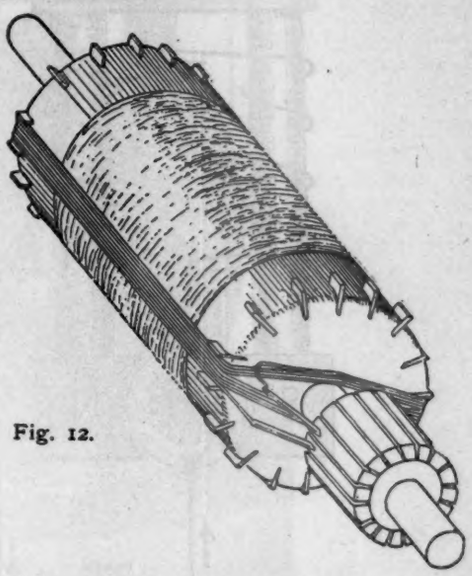


Fig. 12.

METHOD OF WINDING SIEMENS ARMATURE.

The superiority of the very constant current generated by the Gramme machine was so palpable that Siemens was not slow in appreciating it, and we soon find him bringing forward a machine in which, while the long armature is preserved, the single coil with its two-part commutator is replaced by a cylinder longitudinally wound with many coils which, like the Gramme coils, do not overlap each other but lie on different parts of the circumference, are connected to each other around the whole cir-

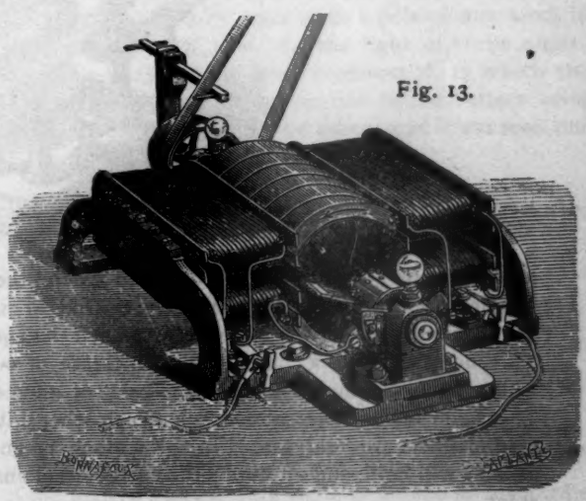


Fig. 13.

cumference, and are connected also to an equal number of brass strips secured to the armature shaft. Fig. 12 shows a new Siemens armature in process of construction, one coil only being in place, and fig. 13 shows a new Siemens machine, the armature with all its coils on, lying in position between the magnet poles.

In what has been said thus far, it has been assumed that

the field magnets were permanent magnets, or, at least, were not dependent for their magnetism upon the machine itself. Small dynamos are sometimes so made, and formerly all dynamos were; but now nearly all field magnets are electro-magnets produced and maintained by the armature revolving between their poles, as in fig. 14. When the armature is motionless, and therefore making no current, no magnetism is evident in the field magnets, except

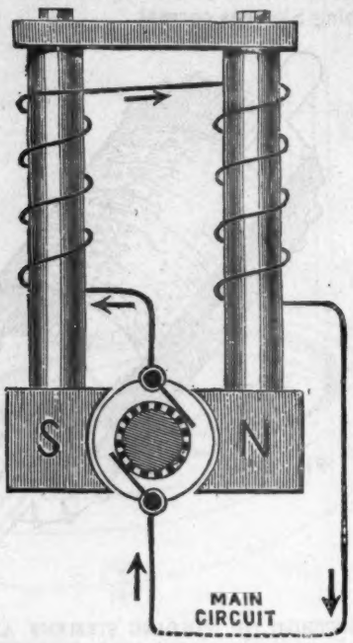


Fig. 14.

a trace of residual magnetism which always exists in a piece of iron that has once been magnetised. When the armature begins to turn, this residual magnetism causes a very slight current in the armature and, therefore, in the external wire, but since the wire is taken around the field magnets before leaving the machine, this slight current goes around the magnets and increases their magnetism. This increase causes a corresponding increase of current which in turn causes another increase of magnetism. These effects continue to react upon each other until the field magnets are "saturated" with as much magnetism as they will hold, and after this the current remains constant.

At the present day, nearly all the constant-current dynamos in the world are modifications—and some of them extremely slight modifications—of the Gramme and the new Siemens, but there is one, the Brush, which is quite original and which is at the same time very extensively used and very efficient and reliable.

In the Brush machine (fig. 15), separate coils, mounted as shown, are revolved rapidly between the poles of powerful magnets. Their action in cutting lines of magnetic force is, of course, precisely the same as that of coils in the Gramme and the Siemens machines, but the manner in which they are connected together and to the outside circuit is entirely different, for, instead of being connected in one series all around the armature and to metal strips lying side by side on the armature shaft, they are connected in pairs, each coil being connected to its opposite. For each pair of coils, there is a separate commutator on the axle, so that if there are eight coils, as shown in the figure, there are four commutators; and these commutators being arranged in pairs with one set of brushes to each pair there are two sets of brushes. The Brush machine is especially applicable to working a large number of street-lamps on one wire, the current generated being of a character capable of overcoming great resistance, or, as it is usually expressed, having high electromotive force.

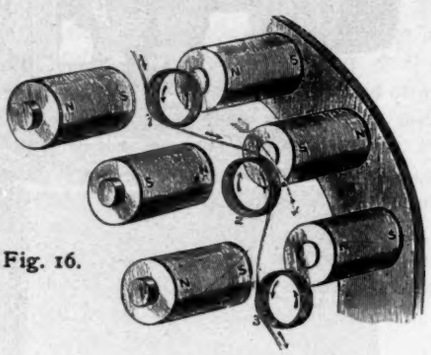


Fig. 16.

We have thus far considered the means of generating currents constant in direction, but for quite a large fraction of the work that electric machines, or dynamos, are required to do, it is not necessary that the current be constant in direction, and in Europe machines giving alternating currents are used in great numbers for running the incandescent lamps employed in interiors, and some of these machines are very large and exceedingly efficient.

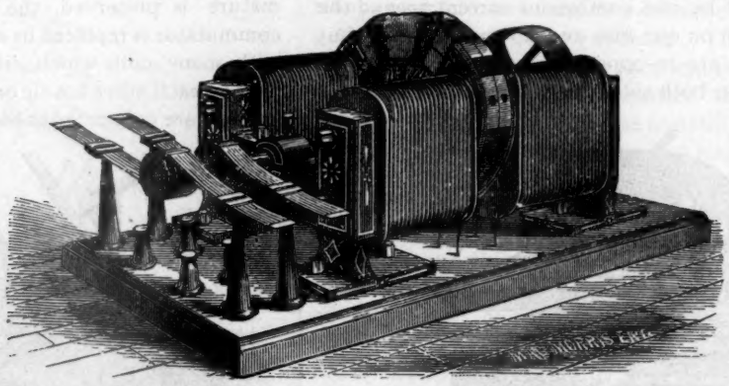
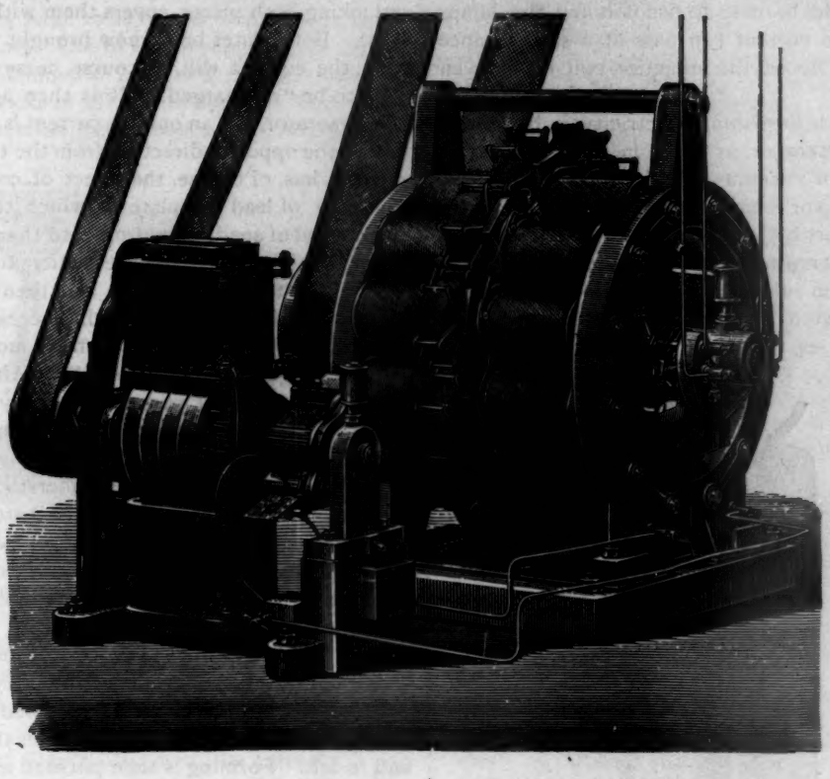


Fig. 15.

Alternate-current dynamos are, for the most part, based on the principle illustrated in fig. 8 (page 504), the ends being bodily transported from a field in which the lines of force run in one direction to a field in which they run in the opposite direction, the direction of current produced at any instant depending upon whether the lines of force are changing from negative to positive or from positive to negative. In constructing machines on this principle, a number of coils connected together but wound in opposite directions, as shown in fig. 16, are mounted so as to lie in the fields between the unlike poles of magnets,

Now, as the shaft rotates, these coils pass between the magnet poles in succession, and we can see that when any coil is approaching or receding from, say, a north pole, its two neighbors are approaching or receding from two south poles; so that contrary and opposing currents would be generated were it not for the fact that, as said above, alternate coils are wound in opposite directions, so that the currents induced in all the coils are added together and form one total current passing around all the coils in succession. But we also see that this current, passing in all the coils, changes in direction each time that the coils change position in the course of a revolution; so that if 20 coils revolve between the poles of 20 magnets, the current is changed 20 times per revolution. If the shaft revolved slowly, say once per second, the alternation would produce a vibrating light very unpleasant to the sight; but since the shaft revolves many times per second, the alternations succeed each other so rapidly that the eye is not quick enough to detect any change whatever, and the light appears perfectly steady. The field magnets, however, must be excited by a constant current, so that the poles will not change, and to accomplish this, it is usual to employ a small constant-current dynamo to send its current around the field magnets, as shown in fig. 17, representing a Siemens alternate-current dynamo, in which the coils are mounted in a shaft turned by a belt, and the field magnets are excited by a small Siemens constant-current machine standing in the foreground.

Fig. 17.



We now come to a system which has been used with considerable success abroad, and which is now being introduced into this country by the Westinghouse Company. It is called the "induction system." It was developed into a practical form mainly by the efforts of Messrs. Gaulard and Gibbs. To comprehend this system it will be necessary to recall Faraday's discovery of the generation of electric currents by the relative motion of coils and magnet poles, and also to remember that Faraday discovered, in addition, that similar effects could be produced if the magnets were electro-magnets, even if the iron coil were absent; and that they could be produced even if the electro-magnet and coils were stationary, but the current in the electro-magnet were made or broken or reversed, the explanation being simply that the number of lines of force embraced by the coil in question was changed not only by the motion of the magnet poles but also by any change in the strength of the magnet pole itself; in other words, that the number of lines of force embraced by a coil near a north pole could be lessened, not only by taking away the north pole but also by making the north pole cease to be a pole of any kind, by making it a south pole. In the light of these experiments, induction coils were constructed, in which two separate coils were wound on one coil, a battery being attached to one but not to the other; and it was seen that

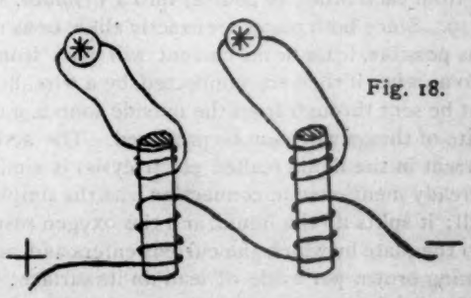


Fig. 18.

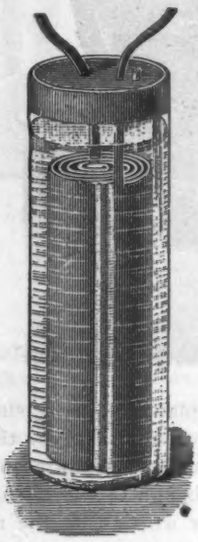
if the battery current were made or broken or reversed or changed in strength, a current called an "induced" current, would, at once, traverse the other coil.

The induction system of Messrs. Gaulard and Gibbs may be understood from fig. 18, in which the main current, which is alternating, goes along the heavy wire which is wrapped around such a piece of iron as shown in the figure, another wire in circuit with a lamp, or several

lamps, being also wound around each such piece of iron. The alternations of the main current induce currents in each of these circuits; but the main current itself does not enter them or any of the lamps. By this system it is possible to safely use a heavy alternating current of greater power than it would be wise to use if it fed the lamps direct, for the main current can pass at a safe distance from the lamps of a house, the induction coil being even outside.

Another system for furnishing electricity is by means of the secondary battery, or, as it is sometimes called, the "storage battery" or "accumulator," the prevailing idea being that it stores up or accumulates electricity that is put into it. The secondary battery is, however, merely a voltaic cell so composed that normally it yields no appreciable current, but which, when subjected to the action of a current of electricity generated by some outside source, is so changed chemically as to be able, after the removal of this current, to give off a current of electricity itself in the opposite direction.

Fig. 19.



The secondary battery in its simplest form and as prepared by its inventor, Planté, consists of two plates of lead in a solution of dilute sulphuric acid. In order to get a considerable surface of lead, Planté rolls two plates (separated from each other, of course) into a cylinder, shown in fig. 19. Since both plates are exactly alike, or as nearly alike as possible, little or no current will pass from one plate to another if they are connected by a wire, but if a current be sent through from the outside source, a different state of things will soon be produced. The action of the current in the liquid (called electrolysis) is similar to that already mentioned in connection with the simple voltaic cell; it splits up the liquid, and the oxygen resulting goes to the plate by which the current enters and attacks it, forming brown per oxide of lead on its surface; while the hydrogen goes to the other plate, and, as it cannot attack this plate, there will soon be in the liquid two surfaces, peroxide of lead and pure lead, which are so different from each other that, after the exciting current has been removed, they will act exactly like the plates of copper and zinc in a simple voltaic cell and give off a current when connected by a wire, this current being opposite in direction to the electrolyzing current. Coincidently with the giving off of this current, the brown peroxide will begin to combine with the hydrogen which, as in the simple cell, goes to the negative pole, and the peroxide will gradually become monoxide, while the pure lead plate will be attacked by the oxygen set free and also become coated with monoxide of lead. The sulphuric acid then, attacking both plates, covers them with white sulphate of lead. Both plates being now brought to the same condition, the current will, of course, cease. The cell is then said to be "discharged." It is then again connected to the generator, and an outside current is again sent through but in the opposite direction from the the first one. This current has, of course, the effect of coating with brown peroxide of lead the plate to which the hydrogen went before, and of sending hydrogen to the plate formerly peroxidized, thus ensuring its reduction to pure lead again. The cell is then discharged, and then charged again in the same direction as at first, the successive chargings and dischargings causing the plates to be more and more eaten into by oxygen, so that eventually both become covered with a spongy layer possessing a very great amount of surface. When layers become sufficiently thick, the battery is said to be "formed"—and the process requires several months. It will be understood that, since the length of time during which the battery can furnish a current depends on the amount of peroxide, and since this depends on the amount of surface exposed, the advantage of the porous layers lies simply in the fact that they possess great surface.

In order to shorten the process of forming, M. Camille Faure conceived the idea of giving both plates a preliminary coating of red lead, which he made into a paste and attached to them, wrapping the plates then in parchment and in felt. Forming is then pursued as before, but since red lead is itself an oxide of lead, and as it is already in a finely divided condition, much less time is required to produce the desired state of things than when pure lead only is used as in Planté's cell.

Since Faure's invention, numberless secondary batteries have been devised, but they differ from Planté's and Faure's only in details of construction, the effort being mainly to reduce the weight of the cell and to support the plates in such a way that they can be in a finely divided condition and possess considerable surface, and yet not break to pieces in use. Secondary batteries are not yet as thoroughly perfected as some suppose, but they are rapidly improving and are coming into extensive use; and doubtless their future is great for many purposes where a dynamo can not conveniently be used, as for running street cars in crowded cities.

From the foregoing, it will be observed that, in order to obtain a current from a dynamo, it is first necessary to burn coal to produce steam, then to expand the steam in a cylinder to produce motion in a steam engine, then to connect the steam engine to a dynamo, which converts the energy of its mechanical motion into the electrical energy of a current. Now, each one of these processes is attended by considerable waste, so that the whole operation is not only complicated but is so extremely uneconomical that only about 10 per cent. of the energy of the burning coal is obtained in the current; and for this reason electricians have labored for years to get electricity from coal direct. Their starting point has been the discovery of Seebeck, that if the junctions of two metals be kept at different temperatures, a current will result; if for instance, a piece of copper (*k*, fig. 20) be placed as

shown on a block of bismuth, *a b*, and one junction, *b*, be heated while the other *a*, be kept cool, a small current will pass, as evidenced by the deflection of a pivoted magnet placed near. All the known metals have been tried, and numberless alloys, in the endeavor to produce a cell operated by heat alone, able to inexpensively generate currents sufficiently large to be of practical use for working lights and motors. One of the largest of these *thermo-electric* cells is Clamond's, in which the junctions are heated, of large blocks of alloy with sheets of iron. The products of combustion pass through flues which bring

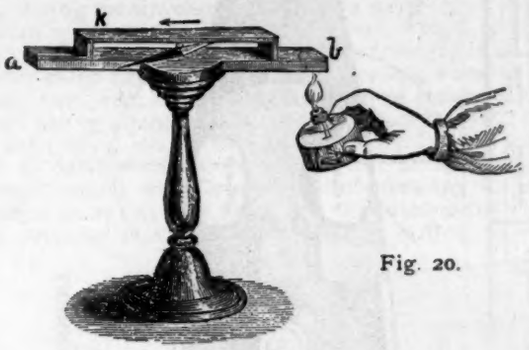


Fig. 20.

them into contact with one series of junctions, the other junctions being cooled by air. It is stated that, with this apparatus, a current has been generated strong enough to support an electric light of considerable power. A curious invention in this line is that of M. Brard, called an "electro-generative brick." The brick is made of prepared carbon, separated from nitrate of potash by a sheet of asbestos. A strip of brass is embedded in each, and the whole is enveloped in asbestos paper, the brass strips protruding. If the brick be now put into a hot fire, wires being attached to the two brass strips, a current, it is said, strong enough to ring a bell, will circulate in the wire, and continue for about two hours.

Though the act of producing electricity from heat direct cannot be said to have yet reached the practical stage, yet it is probably the method of the future; and though investigators are now groping in the dark, progress is surely though slowly being made, and at any time we may hear of the golden discovery which will render possible the safe, cheap, ready and abundant supply of electricity to the world.

RAILROAD ACCIDENTS IN GREAT BRITAIN.

THE report of the Board of Trade, just issued, gives the following summary of accidents and casualties reported to the Board as having occurred on the railroads of Great Britain and Ireland during the six months ending June 30, 1887:

I. ACCIDENTS TO TRAINS, ETC.

Accidents to trains, rolling-stock, permanent-way, etc., caused the death of 6 persons and injury to 241, as follows:

	1887.		1886.	
	Killed.	Injured.	Killed.	Injured.
Passengers	..	195	8	324
Servants of companies	6	46	3	40
Total	6	241	11	364

During the six months, there were reported 18 collisions between passenger trains or parts of passenger trains, by which 64 passengers and 9 servants were injured; 12 collisions between passenger trains and goods or mineral trains, etc., by which 76 passengers and 12 servants were injured; 7 collisions between goods trains or parts of goods trains, by which 2 servants were killed, and 2 cattle dealers and 13 servants were injured; 20 cases of passenger trains or parts of passenger trains leaving the rails, by which 1 servant was killed, and 14 passengers and 4 servants were injured; 4 cases of goods trains or parts of goods trains, engines, etc., leaving the rails, by which 3 servants were killed; 10 cases of trains running into stations or sidings at too high a speed, by which 20 passengers and 2 servants were injured; 54 cases of trains running over cattle (during the six months, 12 horses, 2 ponies, 34 beasts and cows, 62 sheep, 4 donkeys and 1 pig were run over and killed), or other obstructions on the line, by which 3 servants were injured; 2 failures of engine machinery, by which 2 servants were injured; 1 failure of brake apparatus, by which 15 passengers were injured; 2 failures of couplings, by which 1 passenger was injured; 3 slips in cuttings or embankments, by which 1 passenger and 1 servant were injured; and 1 other accident, by which 2 passengers were injured.

The following cases were also reported, but they involved no personal injury: 1 case of a train traveling in the wrong direction through points; 24 cases of trains running through gates at level crossings; 421 failures of tires; 127 failures of axles; 1 failure of a bridge; 132 broken rails; 1 case of flooding of the permanent-way; 3 fires on trains; and 2 fires at stations or involving injury to bridges or viaducts.

Of the 421 tires which failed, 7 were engine tires, 2 were tender tires, 4 were carriage tires, 16 were van tires, and 392 were wagon tires; of the wagons, 290 belonged to owners other than the railway companies; 361 tires were made of iron, and 60 of steel; 13 of the tires were fastened to their wheels by Gibson's patent method, 17 by Mansell's and 2 by Beattie's, none of which left their wheels when they failed; and 3 by other methods, one of which left its wheel when it failed; 21 tires broke at rivet-holes, 6 at the weld, 77 in the solid, and 317 split longitudinally or bulged.

Of the 127 axles which failed, 74 were engine axles, 68 crank or driving, and six leading or trailing; 11 were tender axles, 2 were carriage axles, 37 were wagon axles, and 3 were salt-van axles. Of the wagons 22, including the salt-vans, belonged to owners other than the railway companies. Of the 68 crank or driving axles, 41 were made of iron and 27 of steel. The average mileage of 40 crank or driving axles made of iron was 219,669 miles.

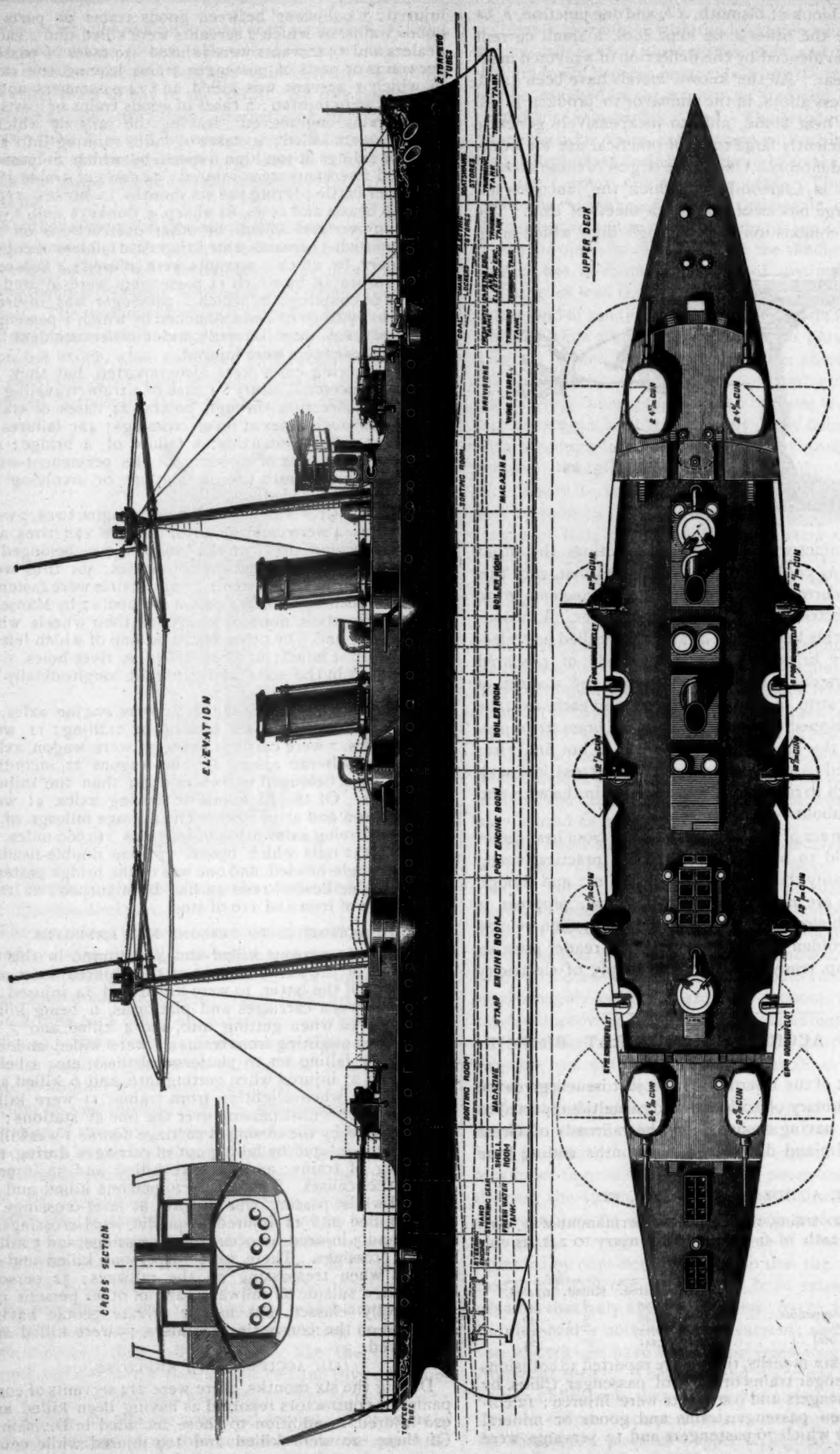
Of the 132 rails which broke, 53 were double-headed, 78 were single-headed, and one was of the bridge pattern; of the double-headed rails 29 had been turned; 22 rails were made of iron and 110 of steel.

II. ACCIDENTS TO PERSONS NOT EMPLOYES.

Of the 194 persons killed and 429 injured in this division, 42 of the killed and 331 of the injured were passengers. Of the latter, 10 were killed and 14 injured by falling between carriages and platforms, 6 being killed and 7 injured when getting into, and 4 killed and 7 injured when alighting from trains; 7 were killed and 232 injured by falling on to platforms, ballast, etc., 1 being killed and 27 injured when getting into, and 6 killed and 205 injured when alighting from trains; 11 were killed and 9 injured whilst passing over the line at stations; 37 were injured by the closing of carriage doors; 1 was killed and 7 were injured by falling out of carriages during the traveling of trains; and 13 were killed and 32 injured from other causes. There were 26 persons killed and 14 injured whilst passing over railways at level-crossings, 12 being killed and 11 injured at public level-crossings, 9 killed and 3 injured at occupation crossings, and 5 killed at foot crossings. There were 79 persons killed and 46 injured when trespassing on the railways; 32 persons committed suicide on railways; and of other persons not specifically classed, but mostly private people having business on the companies' premises, 15 were killed and 38 injured.

III. ACCIDENTS TO EMPLOYES.

During the six months, there were 214 servants of companies or contractors reported as having been killed and 920 injured, in addition to those included in Division 1. Of these, 20 were killed and 109 injured while coup-


ELEVATION
CROSS SECTION
UPPER DECK
BOILER ROOM
PORT ENGINE ROOM
STARB ENGINE ROOM
MAGAZINE
STORING ROOM
MAGAZINE
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MAGAZINE
STORING ROOM
COAL
COAL
COAL

ling or uncoupling vehicles; 2 were killed and 12 injured by coming in contact, whilst riding on vehicles during shunting with other vehicles, etc., standing on adjacent lines; 2 were injured whilst riding, passing over or standing upon buffers during shunting; 11 were killed and 72 injured in getting on or off, or by falling off engines, wagons, etc., during shunting; 3 were killed and 49 injured whilst breaking spragging or chocking wheels; 6 were killed and 38 injured whilst attending to ground-points, marshaling trains, etc.; 3 were killed and 90 injured whilst moving vehicles by capstans, turn-tables, props, etc., during shunting; and 16 were killed and 169 injured by various other accidents during shunting operations; 9 were killed and 34 injured by falling off engines, etc., during the traveling of trains; 2 were killed and 8 injured by coming in contact with over-bridges or erections on the sides of the line during the traveling of trains; 6 were killed and 45 injured whilst getting on or off engines, vans, etc., during the traveling of trains; 4 were killed and 73 injured whilst attending to, or by the failure of, machinery, etc., of engines in steam; 62 were killed and 58 injured whilst working on the permanent-way, sidings, etc.; 2 were injured whilst attending to level crossing gates; 45 were killed and 58 injured whilst walking, crossing or standing on the line on duty; 3 were killed and 22 injured by being caught between vehicles; 4 were killed and 21 injured by falling or being caught between trains and platforms, walls, etc.; 18 were killed and 14 injured whilst walking, etc., on the line on the way home or to work; and 44 were injured from various other causes.

SUMMARY.

Altogether, the number of persons killed and injured on railways in the United Kingdom in the course of public traffic during the six months ending June 30, as reported to the Board of Trade, was as follows:

	1887. Killed.	1887. Injured.	1886. Killed.	1886. Injured.
Passengers:				
From accidents to trains, rolling stock, permanent-way, etc....	..	195	8	324
By accidents from other causes	42	331	43	303
Servants of companies or contractors:				
From accidents to trains, rolling stock, permanent-way, etc....	6	46	3	40
By accidents from other causes.	214	920	169	918
Persons at level-crossings.....	26	14	39	17
Trespassers (including suicides).	111	46	134	42
All persons not classed above...	15	38	23	42
Total.....	414	1,590	449	1,686

IV. MISCELLANEOUS ACCIDENTS.

In addition to the above, the railway companies have reported to the Board of Trade, in pursuance of Section 6 of the Regulation of Railways Act, 1871, the following accidents which occurred upon their premises, but in which the movement of vehicles used exclusively upon railways was not concerned, namely: 2 passengers killed and 69 injured whilst ascending or descending steps at stations; 10 injured by being struck by barrows, falling over packages, etc., on station platforms; 16 injured by falling off platforms; and 1 killed and 35 injured from other causes. Of servants of companies or contractors 433 injured whilst loading, unloading or sheeting wagons; 1 killed and 126 injured whilst moving or carrying goods in warehouses, etc.; 1 killed and 74 injured whilst working at cranes or capstans; 1 killed and 156 injured by the falling of wagon doors, lamps, bales of goods, etc.; 182 injured by falling off, or when getting on or off stationary engines or vehicles; 4 killed and 125 injured by falling off platforms, ladders, scaffolds, etc.; 1 killed and 110 injured by stumbling whilst walking on the line or platforms; 93 injured whilst attending to stationary engines in sheds; 24 injured by being trampled on or kicked by horses; 2 killed and 238 injured whilst working on the line or in sidings; and 1 killed and 128 injured from various other causes. Of other persons, most of whom were transacting business on the companies' premises, 7 were killed and 82 injured, making a total in this class of accidents of 21 persons killed and 1,901 injured.

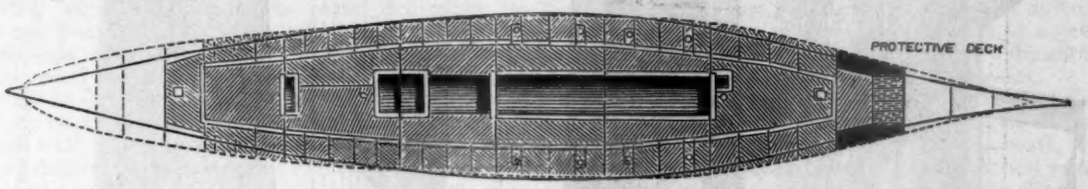
Thus the total number of personal accidents reported to the Board of Trade by several railway companies during the six months amounts to 435 persons killed and 3,491 injured.

The Spanish Cruiser "Reina Regente."

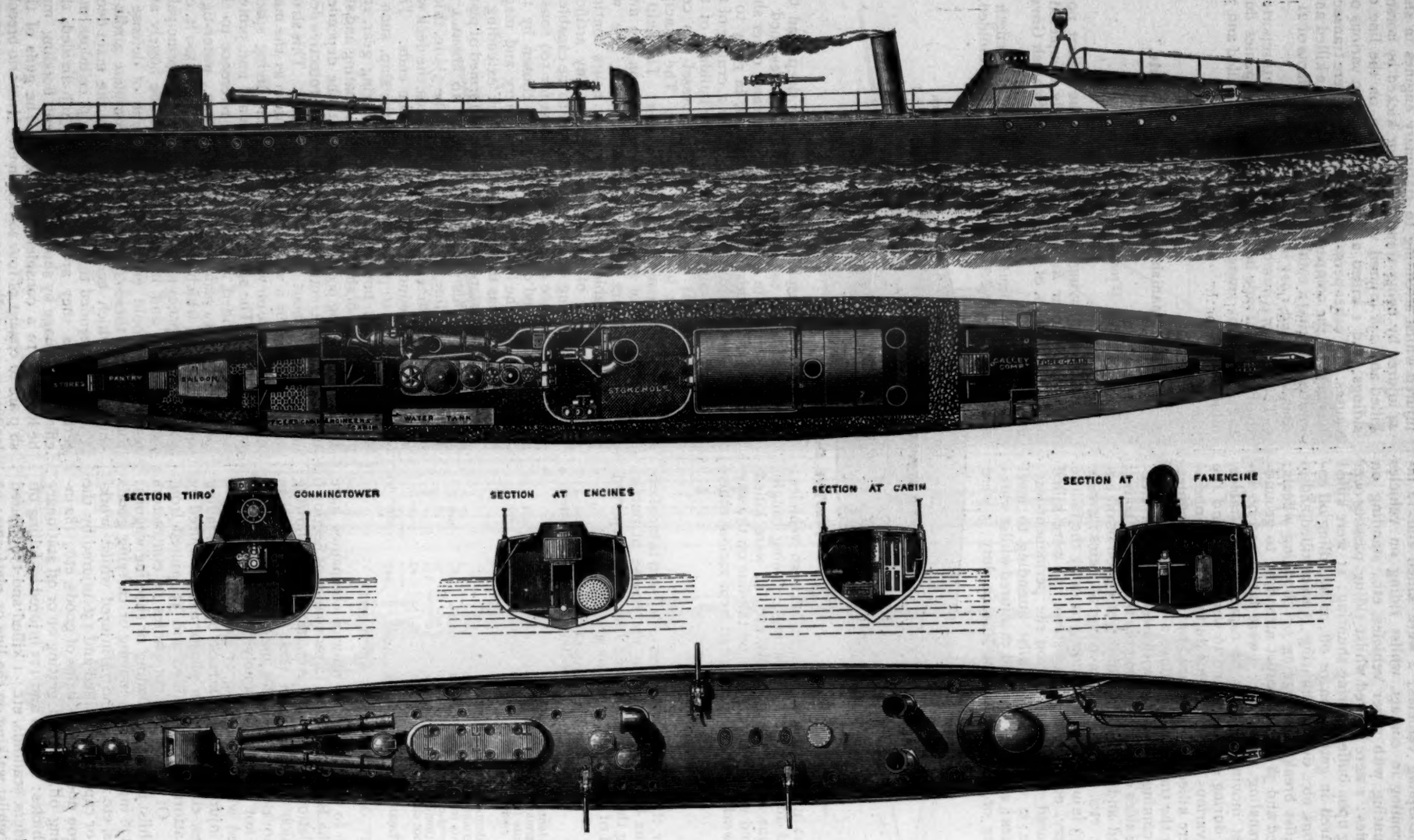
(From the London *Engineer*.)

THE accompanying engravings show the salient points of the new cruiser *Reina Regente* recently completed by Messrs. Thomson, of Clydebank, for the Spanish Government.

The principal dimensions are as follows: Length on water line, 317 ft.; breadth, 50 ft. 7 in.; depth, molded, 32 ft. 6 in.; normal displacement, 4,800 tons; deep load displacement, 5,600 tons. This vessel was designed by Messrs. Thomson in competition with several other shipbuilding firms of this and other countries, in reply to an invitation of the Spanish Government for a cruiser of the first class. The design submitted by the builders of the *Reina Regente* was accepted, and the vessel was contracted to be built in June of last year. The principal conditions of the contract were as follows: The ship to steam at a speed of 20½ knots for four runs on the mile, and for two hours continuously afterward. She was further to be capable of steaming for six hours continuously at a speed of 18½ knots, without any artificial means of producing draft. She was also to be capable of steaming a distance of at least 5,700 knots for 500 tons of coal, at some speed over 10 knots, to be chosen by the builders. Over the length of her machinery and magazine spaces she was to have a sloping deck extending to 6 ft. below the water-line at the side, and formed of plates 4¾ in. thick. This deck was to extend to about 1 ft. above the water-line, and the flat part to be 3⅛ in. thick. Beyond the machinery and magazine spaces, the deck was to be gradually reduced to 3 in. thick at the ends. This deck is intended to protect the vitals of the ship, such as boilers, engines, powder magazines, steering gear, etc., from the effects of shot and shell, but the floating and stability-maintaining power of the ship was to be dependent upon a similar structure raised above this protective deck to a height of about 5 ft. above the water. This structure is covered by a water-tight deck, known as the main deck of the ship, on which the cabins and living spaces are arranged. The space between the main and protective deck is divided, as may be seen by reference to the protective-deck plan, into many strong, water-tight spaces, most of which are not more than about 500 ft. capacity. The spaces next to the ship's side are principally coal bunkers, and may, therefore, exclude largely any water that should enter. The first line of defense is formed inside these coal bunkers by a complete girdle of cofferdams, which can be worked from the main deck. These it is intended to fill with water and cellulose material, and as they are also minutely sub-divided, the effects of damage by shot and consequent flooding may be localized to a considerable extent. The guns of the ship are to consist of four 20-centimeter Hontorio breech-loading guns on Vavasseur carriages, six 12-centimetre



PROTECTIVE DECK PLAN.



TORPEDO BOAT FOR THE SPANISH GOVERNMENT.

BUILT BY YARROW & CO., LONDON, ENGLAND.

guns, eight 6-pounder rapid firing, and eight or ten small guns for boats and mitrailleuse purposes, four of which are in the crow's-nests at the top of the two masts of the ship. We may remark in passing that the builders saw their way at an early period of the construction to suggest an addition to the weight of the large-sized guns, and there will actually be on the ship four 24-centimeter guns instead of four 20-centimeter. The vessel was to carry five torpedo tubes, two forward in the bow, one in each broadside, and one aft; all these tubes to be fixed. To fulfill the speed condition, four boilers were necessary and two sets of triple-expansion engines, capable of developing in all 12,000 H. P.

Now that the vessel has been completely tried, the promises by the builders may be compared with the results determined by the Commission of Spanish officers appointed by the Government of Spain to say whether the vessel fulfilled in all respects the conditions laid down in the contract. The mean speed attained for the two hours' run was 20.6 knots, as compared with 20.5 guaranteed, but this speed was obtained with 11,500 H. P. instead of the 12,000 which the machinery is capable of developing. The officers of the Spanish Commission were anxious not to have the vessel's machinery pressed beyond what was necessary to fulfill the speed conditions of the contract; but they saw enough to warrant them in expressing their belief that the vessel can easily do twenty-one knots when required, and she actually did this for some time during the trial. During the natural-draft trial the vessel obtained a mean speed of 18.68 knots, on an average of 94¾ revolutions—the forced draft having been done on an average of 105½ revolutions. The consumption trial, which lasted 12 hours, was made to determine the radius of action, when the ship showed that at a speed of 11.6 knots she could steam a distance of 5,900 knots. Further trials took place to test the evolutionary powers of the vessel, though these trials were not specified in the contract.

The vessel, as may be seen from the engravings, is fitted with a rudder of a new type, known as Thomson & Biles' rudder, with which it is claimed that all the advantage of a balanced rudder is obtained, while the ship loses the length due to the adoption of such a rudder. It is formed in the shape of the hull of the vessel, and as the partial balance of the lower foreside gradually reduces the strains, the rudder-head may be made of very great service. As a matter of fact this rudder is 230 ft. in area, and is probably the largest rudder fitted to a warship. The efficiency of it was shown in the turning trials, by its being able to bring the vessel round, when going at about 19 knots, in half a circle in 1 minute 23 seconds, and a complete circle in 2 minutes 55 seconds, the diameter of the circle being 350 yards. This result, we believe, is unrivalled, and makes this vessel equal in turning capabilities to many recent warships not much more than half her length.

The New Spanish Torpedo-Boats.

(From the London *Engineering*.)

THE accompanying engravings are illustrations of two torpedo-boats, the *Azor* and the *Halcon*, which have lately been built for the Spanish Government by Messrs. Yarrow & Co., of Poplar.

These boats are exactly alike in all respects; they are 135 ft. long by 14 ft. beam, being of the same general dimensions as the No. 80 torpedo-boat, lately completed by the same firm for the Admiralty, which is the largest and fastest torpedo-boat in the British Navy.

The general arrangement of these boats is so well shown in the illustrations as to need but little description. The engines are of the triple-compound type, capable of indicating 1,550 H. P., steam being supplied by one large locomotive boiler, which is in accordance with the usual practice of the makers; as, by using a single boiler, great simplification of the machinery is secured, and less room is occupied than if two boilers were used. While in some torpedo-boats there has been trouble with the locomotive type of boiler, it is a fact that Yarrow & Co. have already constructed a great number of locomotive boilers of the exceptional size adopted in these Spanish boats, and they have turned out perfectly satisfactory in every respect in actual service.

The forward part of the boat is provided with two torpedo-ejecting tubes, as usual; near the stern, on deck, it is proposed to erect turn-tables, with two torpedo-guns for firing over the sides, a plan already adopted by several governments.

The trials of the *Azor* took place about two months ago, giving a speed during a run of 2¾ hours of 24 knots an hour, with a load of 17 tons on board. Since her trial she has steamed out to Spain, having met during a portion of the voyage with very bad weather, when her sea-going qualities were found to be admirable.

The *Halcon*, whose official trials took place recently, obtained a speed of 23.5 knots an hour, carrying a load of 17 tons. She is now being pushed forward to completion, and will leave for Spain in a week or two. It may be remarked that a speed of 24 knots in a boat only 135 ft. long, under the Spanish conditions of trial, is by far the best result that has ever been attained in a vessel of these dimensions. There is, however, no doubt that a still higher speed would have been obtained, had the length of the boat been greater; but the authorities desired to keep within the smallest possible dimensions, so as to expose as small an area as practicable to the fire of an enemy, it being clearly evident that this is a consideration of the first importance in an unprotected war vessel.

In conclusion, we would add that the hulls of these two Spanish boats are of much greater strength of construction than is usually adopted in torpedo-boats, it having been found that strength sufficient for actual service has often been injudiciously sacrificed for the sake of obtaining exceptional speeds. Judging from the numerous accidents which took place at the recent trials off Portland, we have no doubt that in the future our naval authorities will be quite ready and willing to sacrifice a little speed to obtain vessels which are most trustworthy. The necessity for this, we are convinced, will be conclusively shown, if ever torpedo-boats are engaged in actual warfare, not only as regards strength of hull, but also as regards the machinery.

It must be admitted that the engines and other machinery at present used in this class of boats can only be handled successfully by men of exceptional skill and training; and in time of war such men could not readily be procured.

THE NEW AND THE OLD NAVY.

WE give below in condensed form a number of notes from various sources in relation to the new ships and guns for the Navy, and other naval matters:

THE NEW TORPEDO-BOAT.

The bids for the construction of a new torpedo-boat were opened at the Navy Department, November 1. The bids were two in number, one from the Vulcan Iron Works, of Chicago, at $84,800, the other from the Herreshoff Manufacturing Company, of Bristol, R. I., at $82,750.

This vessel is to be of the best and most modern design; to be constructed of domestic steel, and to have the highest attainable speed. Premiums will be paid at the rate of $1,500 for each quarter knot in excess of 23 knots, and including 24 knots; $2,000 for each quarter knot in excess of 24 knots. Should the speed fall below 22 knots a penalty of $4,000 will be enacted, and if below 20 knots the Department reserves the right to reject the boat. The trial is to consist of a continuous run of three hours' duration in smooth water.

The approximate length of the boat is 135 ft.; beam, 15 ft.; depth under spar deck, 6 ft. 2 in.; draft forward, 2 ft.; aft, 5 ft. 2 in.; displacement at load water line, about 100 tons. It is to have a ram bow, and the stern is to be adapted to twin screws. The deck is to be elliptically curved, and is to have a maximum rise of not more than

2 ft. 4 in. at the greatest breadth of beam. There are to be two conning towers, placed approximately 30 ft. from the bow and 30 ft. from the stern respectively. From the forward conning tower to the stem of the boat the deck is to assume the form of a whale-back, so as to completely enclose and cover two torpedo-launching tubes. The main engines are to consist of two sets of compound triple-expansion condensing engines, with direct connection to propeller-shafts, with separate engines for working the circulating and air pumps.

COAST DEFENSE.

As noted last month, the Naval Board on Coast Defense has nearly completed its report. As then indicated this report will recommend a system of defense consisting of monitors supported by auxiliary craft, such as rams and torpedo-boats. The Board has found that the $2,000,000 appropriated by Congress for this purpose will be sufficient to establish at least one unit of the system. The monitor *Miantonomoh* has been selected as the vessel which will be center of the unit, and she will be aided with several fleet rams which in turn will be accompanied and protected by small, speedy torpedo-boats and fish torpedoes. If this unit should be found to work harmoniously and efficiently the system can be indefinitely extended from year to year without requiring a great expenditure at one time.

One important point, remaining unsettled, however, concerns the auxiliary craft. The rams brought before the Board are of two general classes. The first class is a type of heavy ram intended to crush in the side of a ship by a powerful blow. The second class, which meets with more favorable consideration at the hands of the Board, includes what is known as the Berdan system. These rams are double-ended, have ferryboat bows, so as to prevent the submarine ram from being twisted off when an enemy is struck at an angle, and being equipped with propellors at each end are capable of turning as on a pivot. They are also equipped with diving torpedoes attached to cables, so as to swing up and explode beneath a vessels bottom, regardless of the net now relied upon as a protection against torpedoes.

THE NEW CRUISERS.

Work on the *Charleston* at the Union Iron Works in San Francisco is now well advanced. The vessel is framed and has received the outside plating up to the protective deck, and the water-tight bulkheads have been put in the hull.

The material for cruiser No. 5, which is to be built at the same yard, has been ordered, and work will soon be begun.

NAVAL ORDNANCE.

The Chief of the Naval Bureau of Ordnance, Commodore Montgomery Sicard, presents the following estimates for the fiscal year ending June 30, 1889: General expenses, $1,122,225; toward the armament of vessels authorized, $2,000,000. Of the cannon for the *Chicago*, *Boston*, *Atlanta* and *Dolphin*, there remain incomplete but six, which will all be completed in a few months. Contracts have been made for 78 other forgings for the 6-in. gun, 4 for the 8-in., 24 for the 10 in. and 2 for the 12-in. Those for the 6-in. are beginning to come in and will be taken in hand at once. The Bethlehem Iron Company will be prepared to deliver by August 1, 1888, when it is expected that the supply for large and small forgings will be ample. The 6-in. and 8-in. calibers have stood satisfactorily and statutory test for guns, carriages, and equipments, 10 rounds for each caliber.

The guns of the *Atlanta* and *Boston* have been, besides, fired a large number of times in ranging and in practical tests, etc. No defects have been developed. The two 8-in. guns of the *Boston* have been finished and proved. They are hooped to the muzzle, and are fine specimens of work. The 8-in. guns of the *Chicago* are being machined by the South Boston Iron Works and by the West Point Foundry Association, two at each place. One 10-in. gun has been finished and mounted for proof; another is nearly finished, and a third has been commenced at the Washington yard, from 10½-in. English forgings, intended for the *Puritan*.

The Duponts have not yet fully succeeded in developing a powder suitable for use in the chamber of the 8-in. gun, though they have submitted a sample from which an order has been given for a supply for the 8-in. guns of the *Boston* and *Chicago*. There is also a supply for a trial of the 10-in. gun as soon as it is mounted and no serious trouble in obtaining powder for the 10-in. gun is anticipated. No deterioration in the American brown powder has been noticed thus far, and it is hoped it may prove to have good keeping qualities, though a greater length of time and service is necessary in order to settle this.

The manufacture of cast-iron projectiles continues, but little or no success has attended the attempt to secure those of cast-steel, nearly all the castings being more or less porous. A few armor-piercing shells have been purchased from the St. Chamond Company in France. The Chrome Steel Company, of Brooklyn, N. Y., has made a number of very good 6-in. armor-piercing shell forgings, but those attempted for the 8-in. were not so good. It is hoped that other attempts will be more successful.

The bid for steel cast guns has not been acted on. The report refers to the establishment of a factory for making Hotchkiss guns in this country; also to the necessity of more money for the armament of the new ships.

At the Washington gun factory, the foundations for the 40-ton crane supports have been mostly laid.

The excavation for the foundation of the large gun shop is three-fourths completed, and the material for its construction has been advertised for and some of it delivered.

The traveling cranes are advertised for, and the machine tools will be speedily.

The naval proving ground has continued to do satisfactory work, and more money is needed for it. No success has thus far attended the selection of a new site. The ground is preparing for the test of the Clark deflective target. The neighborhood of the town and other buildings and the proximity of two lighthouses to the range make it necessary to provide very fully for the confinement of the shot within the shelter to be erected about the target. Great care will be observed in this matter, and it is thought that no danger will ensue from the trial.

Many plans and designs of torpedoes have been submitted, and some are under examination and trial. There is much need of a special vessel, which could be used both for experimental purposes and as a training ship.

THE GENERAL CONDITION OF THE NAVY.

In his annual report to the Secretary of the Navy, Admiral Porter points out various defects in the navy regulations which render them in some cases almost unintelligible, and suggests that a board be created to revise them. He alludes to the high ability necessary for officers of the Engineer Corps, on which depends the efficiency of ships of war, and regards it as hardly within the bounds of possibility that any one man can be a good line officer, engineer and marine officer. No man can gain a sufficient knowledge of the nautical part of his profession by passing half of his time in the engine-room and the other half on deck. The Admiral says it would be as difficult efficiently to combine the duties of line officer and engineer as to mix oil and water, and holds that the education of an engineer can only be secured by special training.

In considering the question of coast defenses, the Admiral states that the following harbors are entirely defenseless against a single iron-clad: New-York, Boston, San Francisco, lake ports, Hampton Roads and Norfolk, New Orleans, Philadelphia, Washington, Baltimore, Portland, Me., Rhode Island ports, Key West, Charleston, Mobile, Savannah, Galveston, Pensacola, Wilmington, N. C., San Diego, Cal., Portsmouth, N. H., to say nothing of many other places of greater or less importance. Two heavy iron-clads could begin at the easternmost point and proceed along the coast to Texas, having them all under contribution. In time of war, says the Admiral, the torpedo system will be useless for defense in the absence of proper fortifications and guns. For the event of war

we are no more prepared than we were a year ago, although we have made a beginning simply to repair the waste in our navy for the past 25 years. In the opinion of the Admiral, the first step toward the protection of the coast should be the construction of a squadron of heavy iron-clads that could be ready at a week's notice to anchor off shore and resist an approaching enemy. If defeated, this force could retire to the protection of the forts, where, united, they could offer more than twice the resistance they could offer singly. The Admiral argues at length in favor of subsidies for shipping, and points to the success of the system in England, Germany and France.

Touching the *personnel* of the Navy, he says it requires the most careful re-organization, and means should be adopted to infuse new life into it. As regards promotion, the service is at a standstill. Many officers who are Ensigns should be Lieutenants, Lieutenants should be Lieutenant-Commanders, the latter should be Commanders, and Commanders, Captains. A Captain should be able to reach the grade of Rear-Admiral by the time he attains the age of 52 years, so that the Government could obtain some service from him in that grade. Under present circumstances it often happens that an officer goes upon the retired list as soon as he is promoted to the grade of Rear-Admiral, having attained the age of 62 years. No officers should be over 40 years of age when commissioned a Captain or 35 when promoted Commander. The officers in the lower grades should be young men in robust health, active and energetic, to enable them to perform the varied duties of their profession, and should not be allowed to remain too long without promotion. A law providing that commissioned officers of the Navy, with good records, be allowed to retire from active duty after 30 years' service, with promotion to the next higher grade, would afford a great relief and help bring about a more rapid promotion, so that in the course of a few years we might expect to see a more hopeful feeling among the younger officers. The older ones have the goal of their ambition in sight and may hope ultimately to reach it, but to the youngers ones, at the present time, the prospect is not cheering. Some of the more aspiring are seeking in private employment the advancement they fail to receive in the Navy.

THE OLD NAVY.

Commodore T. D. Wilson, Chief of the Bureau of Construction and Repairs, has submitted his annual report to the Secretary of the Navy. In view of the additional duties devolving upon the Bureau in connection with the designing and building of new vessels, he asks that an Assistant Chief of the Bureau be authorized by law. He renews his recommendation that two new vessels of about 1,000 tons each be built to replace the training ships *Saratoga*, *Jamestown* and *Portsmouth*, which cannot possibly be kept in service much longer, and he asks that special authority be given for the repair of the historic sloop-of-war *Hartford* at a cost of $175,000. Relative to the adaptability of the single-turreted monitors to coast and harbor defense, Commodore Wilson says :

"They are now a considerable expense to the Navy, as they must be taken care of, and, not being in proper repair, they are of no use to the country. If these vessels are to be kept on the naval list they should be placed in perfect repair and be fitted with such modern rifles as they are capable of carrying. Within six months all of these vessels could be put into the same state of efficiency as they were at the time of their construction at an expenditure of about $500,000. This would give 13 coast-defense vessels actually available, armed with 15-in. smooth-bore guns. These guns could be replaced as rapidly as possible by rifles. By no other means could the same amount of money be spent to give the country such a valuable return."

Tables attached to the report show the exact condition of every vessel in the Navy. Of the wooden vessels it is said : "The *Trenton*, launched in 1876, represents the latest and best type of wooden steam cruiser, and will be useful and valuable as a cruiser for several years to come. With the *Omaha* and *Vandalia*, second-rates, she can probably be continued in the service nine years longer; the *Lancaster*, with new boilers, six years; the *Brooklyn* and *Richmond*, five years, and the *Pensacola*, three years. Of the third-rates the *Mohican* can be continued in service nine years; the *Adams*, *Alliance*, *Essex*, *Kearsarge*, *Enterprise*, *Tallapoosa*, *Yantic* and *Nipsic*, for five years; the *Juniata*, *Ossipee*, *Swatara*, *Galena* and *Marion*, four years longer. The *Quinnebaug* and *Iroquois* will probably be condemned by law on survey. It will thus be seen that in three years we shall have 21 of these vessels remaining, in six years only 4, and in nine years the entire wooden navy will have disappeared.

COAST DEFENSES OF THE UNITED STATES.

Two important official documents bearing on the queston of Coast Defense have been recently submitted. Both are given in a condensed summary below :

THE ENGINEER CORPS.

The annual report of General Duane, Chief of Engineers, to the Secretary of War, shows that the number of officers in the corps at the end of the last fiscal year was 109. Beyond reference to the attached reports of officers in charge of improvements, the subject of river and harbor improvements receives little mention in the report, which is largely devoted to a statement of the condition of sea-coast and lake-front defenses. On this topic General Duane says that many of the works are dilapidated, and economy requires that they should be kept from decay. Special attention is invited to the estimates for the protection of Fort Niagara, N. Y., which is regarded as of great value to the military service. The estimates submitted aggregate $5,234,000, including $2,840,000 for the construction of gun and mortar batteries, $175,000 for protection, preservation and repair of fortifications, $1,860,000 for submarine mines and appliances for closing channels, and $30,000 for torpedo experiments. In a report upon the subject of fortification made by the Board of Engineers, which is included in General Duane's report, it is said :

"It must be evident that immediate action is demanded to place our sea-coast defenses in proper condition to resist the attacks of an enemy. From the differences of opinion which exist among certain non-military experts as to the character of armor to be used in land defenses, the impression has been created that this matter is an unsettled and tentative condition and that the policy of inaction now existing should still continue. But the facts will not warrant this conclusion, as more than nine-tenths of the armament recommended for our sea-coast is not to be mounted behind iron protections, but in the rear of earthen covers surmounting and shielding the masonry, magazines bomb-proofs and store rooms. Particularly is this true of the rifled mortars, which must hereafter play an important part in the defense of our channels and fair ways, and there is no reason why the erection of the batteries required for them should be delayed a single month. In a word, proper sums may be judiciously expended and much progress toward placing our coasts in a defensive condition may be made—indeed, must be made—before the question of armor demands consideration."

In accordance with the instructions of the Secretary of War the Board has also submitted preliminary plans for the defense of the most important sea-board harbors. On this point it says : "No iron armor is estimated for because more extended defenses can be obtained by investing the funds in other preparations equally necessary and less costly. Such works are mortar batteries and disappearing gun batteries, lifts and the casemates, shafts and galleries needful to establish a defense by submarine mines." Two typical designs prepared by the Board, which are said to meet all modern requirements, are for fortifications constructed of sand, covering the masonry and bomb-proofs. The report says that no armor is now or ever will be required for such defenses. It is believed that disappearing carriages can be constructed which will carry 12-in., 50-ton rifled guns, and an appropriation is suggested sufficient to place a few of these guns and carriages at each of the principal ports. The plan of defense by mortar and gun

batteries recommended by the Board involves an expenditure during the next fiscal year of $2,840,000, which it is proposed to divide among the ports as follows: New-York, $690,000; San Francisco, $460,000; Boston, $280,000; Hampton Roads, $250,000; New-Orleans, $210,000; Philadelphia, $210,000; Washington, $80,000; Baltimore, $60,000; Portland, $290,000; Narragansett Bay, $290,000. The plan also contemplates the preparation of casements, cable shafts, etc., to the number of 26, distributed as follows: At New York, 5; at San Francisco, 5; at Boston, 5; at Hampton, 2; at Philadelphia, 2; at Washington, 1; at Baltimore, 1; at Portland, 3; at Narragansett Bay, 2.

THE ORDNANCE DEPARTMENT.

General Benet, Chief of Ordnance for the Army, in his annual report shows his expenditures for the year to have been $1,597,652. In addition to the regular estimates he asks for the coming year $1,500,000 for steel-gun forgings and $550,000 for the development of the present Government plant into properly equipped shops adequate for manufacturing guns in quantity, $500,000 for 12-in. rifled mortars, and an appropriation to test some different types of mortar carriages. "This question is one of great urgency and should not be postponed any longer from the want of money to investigate it. The same is equally true as regards the general subject of gun carriages. Experimental types should at once be procured and tested for the different calibers of steel sea-coast guns, and standard types adopted. More stress is laid on mortar carriages, simply for the reason that is very probable that we shall have mortars ready for mounting before we have guns. But for either class of piece, considerable time will be required for establishing the details of construction of a properly constituted carriage." The manufacture of an improved limber, caisson, battery wagon and forge for the new field-guns is to commence at once for issue and trial, and $225,000 is asked for the purchase of steel guns, their carriages and ammunition. This will procure not less than 60 steel guns, fully equipped and supplied with ammunition; or taking the 3.2 in. guns now on hand and under manufacture into consideration, it should ensure the full and proper equipment of 100 field guns.

An account is given of the trial of the 8-in. breech-loading steel rifle, which has been fired 100 rounds without erosion or appreciable enlargement. The ballistic results, that is to say, the energy developed in the projectile, exceed the published results of any gun of like caliber extant. As regards accuracy, so far as that has been tested, it was ascertained, as stated in my last report, that for a range of 3,000 yards, or nearly 1¾ miles, the shooting was as follows: Target 30 by 40 ft.; Mean vertical deviation from center of impact, 1.90 ft.; mean horizontal deviation, 1.56 ft.; mean deviation, 2.46 ft.; or the centers of all the shot holes were contained within a circle of 6½ ft. diameter.

An account is given of the concentration of gun plant at Watervliet, and of the controversy with the South Boston Iron Works, touching the present right of possession of two lathes and one traveling crane, the property of the United States at the South Boston Foundry.

The status of the work on the manufacture of the several experimental guns is about as follows: The casting of the 12-in. breech-loading rifle, cast-iron, tubed with steel, has been made and is ready to receive the tube; breech mechanism made but not fitted. The other, which was nearly completed at the close of the last fiscal year, has since been completed. The wire winding of the two cast-iron 10-in. breech-loading wire-wrapped guns has been completed. The 12-in. breech-loading mortar under fabrication by contract with the South Boston Iron Works has been completed and sent to the proving ground for trial. It is expected that a record for accuracy of fire and endurance will be obtained from this piece early in the coming winter, so that a decision can be reached as to the relative merits of breech-loading and muzzle-loading mortars.

The forgings for the 10-in. breech-loading steel rifle have all been accepted. The first tube and jacket delivered by Sir Joseph Whitworth & Co., the manufacturers, were rejected after test, as they fell below the prescribed physical qualities, and were returned to England. The second set of forgings was delivered during the past year and tested with better results. The breech mechanism forgings for this gun have been accepted and delivered.

In the manufacture of these 8-in. rifle forgings, a satisfactory jacket was only obtained after repeated failures and repeated retreatment of the metal, owing to the inadequacy of the present plant at the Midvale Steel Works for such large work. But the manufacturers, it would seem, triumphed at last over their limitations—a thorough knowledge of their art enabling them to attain a success in spite of inadequate facilities. Another very encouraging sign, in the development of our steel industry, is to be observed in the early success of the Cambria Iron Works in meeting the high standard of excellence required under the specifications.

In view of the success thus far attained by our steel makers, it is apparent that all that is now required to make it feasible to produce the largest gun forgings of suitable quality in the country is the assurance that the outlay for necessary plant will prove remunerative.

The 5-in. breech-loading siege gun and its carrriage, and the 7-in. breech-loading howitzer, which were under fabrication at the Watertown Arsenal, have been completed and sent to the proving ground. The powders and projectiles required for their trials are now being procured, so that both of these guns should be heard from at an early day.

The forgings for the breech mechanism of the 10-in. gun have been delivered.

The forgings for the 8-in. breech-loading rifle have been completed and delivered. The tube and jacket forging for this gun is the largest yet made, or attempted in this country.

General Benét presents an argument in behalf of heavy guns of position, adding that "as a projectile force gunpowder yet stands supreme." Referring to the success of the "dynamite torpedo gun," as he calls it, General Benét shows its advantage over the fixed mine, but adds: "It is not intended, by implication even, that fixed mines are to be abandoned, but on the contrary, the two systems supplement each other into a vastly more powerful combination of explosives, and become a most essential adjunct to the heavy guns of great range and power, which are, of necessity, as armor-piercing weapons, the basis of all armament for coast defense. I would recommend the purchase of one of these guns, say of 12-in. caliber, for exhaustive trials of gun and projectile, with the object of determining the full extent of their capacity and fitness for coast defense."

Experiments with the Stevens dynamite shell have shown sufficient promise to justify a more extended trial, and the firings will be continued at an early day. Types of the best pneumatic gun carriages known here or elsewhere should be provided, as aids to the study and development of this vital necessity. A trial of the improved Powlett carriage should be authorized by an appropriation.

The question of a reduced caliber for small arms is now under consideration by the Department. General Benét says: "An effective and simple magazine gun has become a necessity, but from the little that can be learned of the magazine systems said to have been adopted abroad, I am persuaded that nothing is to be gained by haste at this juncture, but that the Springfield arm will continue to admirably serve our purpose and the best interest of the Army, long enough to enable us to determine finally on a magazine gun that will do credit to the inventive genius of our people."

There were 41,106 rifles and carbines manufactured at Springfield during the year. The favorable view of the Morse movable-base cartridge has been fully confirmed by the reports thus far received from five of the companies to which it was issued for trial. A large appropriation for cartridges and target material is recommended, the resources of the Department in meeting in a liberal spirit the demands for target practice being overtaxed.

LOCOMOTIVE-BOILER EXPLOSIONS ON BRITISH RAILROADS.

(*Continued from page 510.*)

WE continue below the summary of the reports made by the Inspectors to the British Board of Trade on the locomotive-boiler explosions occurring on the railroads of that country.

INSPECTORS' REPORTS.

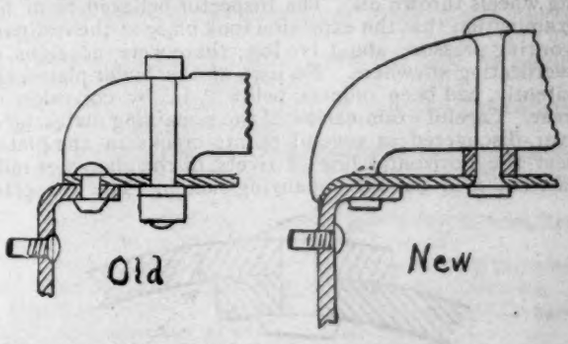
January 29, 1858, the boiler of a locomotive on the Llanelly Railway exploded near Pantyffnwn. The engine was hauling a ballast train at the time, but had just stopped for a switch to be opened. The fireman was hurt, and three boys who stood by the track were killed. The force of the explosion was mainly upward, and the boiler was torn to pieces, the shell being found in four pieces. The tubes were torn out and thrown on the tender. The engine had six wheels coupled, with 14½ × 16 in. cylinders, and was built in 1841. The boiler was of old pattern and was a cylinder of iron 51 in. diameter and 12 ft. long, the plates $\frac{7}{16}$ in. thick. It had an internal tube of ½-in. iron, 24 in. diameter and 8½ ft. long, which tube carried the grate at one end and had a combustion chamber, also of ½-in. iron, attached to it at the other. The smoke-box and chimney were at the same end as the fire-box, and 68 iron tubes, 2 in. diameter, led from the combustion chamber to the smoke-box. The boiler was repaired in 1851 and again in 1857, when several new plates were put in, and 18 new stays were added, several of the tubes being taken out. The Inspector found that the old plates in the shell were worn down in places from $\frac{7}{16}$ to $\frac{5}{16}$ and ¼ in., and believes that these worn plates were too weak to carry the ordinary pressure.

February 8, 1858, the boiler of an engine on the Brighton Railway exploded while standing at Catterham Junction. The copper fire-box gave way just below the fire-door, and the fireman was killed by escaping steam. The back sheet which gave way was found to have been reduced from ⅞ in. to ¼ in., probably by friction from the coke in firing. The engine was nine years old and had run about 200,000 miles. The explosion was probably due to the weakening of the back sheet.

June 11, 1858, the boiler of an engine on the Lancashire & Yorkshire line exploded just after the train had stopped at Lowmoor. The engine was a four-wheel coupled goods engine, with 15 × 24-in. cylinders and 5-ft. drivers; the boiler was 11½ ft. long and 45 in. diameter of barrel, with 121 brass 2-in. tubes. The iron plates were $\frac{7}{16}$ in. thick. It was built in 1846 and had new tubes in 1855 and again in 1858. The usual pressure was 75 lbs., and the safety-valve could not be changed by the engineer. The central plate of the barrel was entirely torn off and was thrown 210 ft. away; the rest of the boiler was not much injured. The fireman and a trackman, who stood near, were killed. The boiler had been patched, but not on the plate which gave way. That plate was very badly corroded, the iron being eaten out in round holes, some of 1 in. diameter; at several points these holes ran together, reducing the thickness of the plate to $\frac{3}{8}$ in. and even less. This corrosion was probably the cause of the failure.

July 24, 1858, the boiler of a locomotive on the North British line exploded at Bournmouth, where the train had just stopped. The engine was a goods engine with 18 × 24-in. cylinders and six-coupled wheels 57 in. diameter. The boiler barrel was 46 in. diameter and 10 ft. long. The fire-box was of $\frac{7}{16}$-in. copper, with 8 roof-stays or crown-bars. Two of these roof-stays gave way, and the fire-box collapsed, the crown-sheet and side-sheets being forced down and the rivets stripped off. The ordinary working pressure was 100 lbs., but from the evidence in the case, the Inspector believes that the area of the safety-valve was insufficient, and the pressure had run up to 145 lbs. and probably more.

August 16, 1859, the engine of a psssenger train on the Southeastern line exploded its boiler just as the train stopped at Lewisham. The engine was 10 years old; it had 15 × 22-in. cylinders, four-coupled wheels 66 in. diameter and leading wheels 42 in. diameter. The usual working pressure was 90 lbs. The fire-box was 42 in. long, 36 in. wide and 54 in. deep. The copper plates, originally ½ and $\frac{7}{16}$ in., had been reduced to $\frac{5}{16}$ and in some places to ¼ in. The effect of the explosion was to lay the crown-sheet of the fire-box, with all the roof-stays close down on the tube-sheet, tearing away the side-sheets about 12 in. from the top, and blowing out the grate and ash-pan. The crown-sheet was separated from the tube-sheet for about 27 in. The Inspector says: "The crown of the fire-box was stayed by 8 roof-stays 41 in. long, placed 4¼ in. apart and secured by ¾-in. rivets 1⅜ in. apart; but it will be noticed that the length of these roof-stays is less than the width of the fire-box, so that their ends do not rest on the walls of the fire-box; and in some places it is evident that the caulking has diminished the thickness of the plates. * * * * The fracture took place in the front plate close to the edge of the top plate and in a straight line coinciding with the line of the caulking, and on examination a crack in the copper, 30 in. long, was found. The marks of the ends of one or two of the roof-stays which projected furthest toward the front plate were apparent on the edge of the fracture, so that if the ends of the roof-stays had been brought further forward and had rested on the upright front plate, instead of ending on the curved and weakest part, it is probable that the explosion would not have occurred, notwithstanding the crack. There is no doubt that the explosion commenced at the front of the top of the fire-box, and at about the ordinary working pressure. * * * * The accompanying sketches show the manner in which the roof-



stays were put on this fire-box, and also (in the figure marked 'New') the manner in which they are now put on by the Southeastern Company, and the mode adopted to avoid caulking."

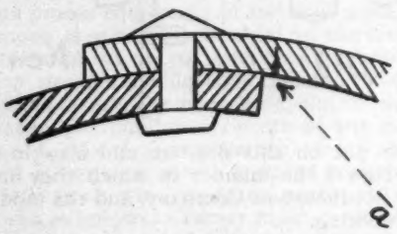
October 17, 1859, the boiler of the locomotive of a freight train on the South Yorkshire road exploded near Wombwell, just as the engineman had shut off steam. The engine had 16 × 24-in. cylinders and six wheels, 54 in. diameter, all coupled. The boiler barrel (of iron) was 48 in. diameter and 10 ft. 4 in. long; the copper fire-box was 4 ft. 6 in. long. There were two safety-valves. The engine had a light train and was blowing off steam just before. The fire-box was nearly uninjured in the explosion; the barrel was torn in two pieces, one being thrown into the ditch beside the track, the other nearly 400 ft. away. The steam dome was torn off and also thrown about 400 ft. away. The boiler plates were found to be badly corroded, in some places eaten more than half through. The explosion is believed to have resulted from weakness of the boiler, due chiefly to corrosion.

March 13, 1860, the boiler of a freight engine on the South Devon road exploded while the engine was doing some shifting at Totnes. The engine had 17 × 24-in. cylinders, with six 57-in. wheels, all coupled; it was five years old and had been repaired about a year before. The explosion tore off the outer fire-box shell, the force acting upward and to the left, and pieces of the shell were thrown through the freight shed and some distance away. This outer shell was of $\frac{7}{16}$-in. iron. The fire-box itself was of copper and stayed to the outer shell by copper stay-bolts, a number of which were torn out and carried away with the pieces of the outer shell. There were no signs

of low water or overheating. The plates, when examined after the explosion, were found to be badly corroded, in some places eaten away so that not more than $\frac{3}{16}$ in. thickness of metal was left. The explosion was attributed mainly to this corrosion, although the Inspector thought that the boiler was not strongly braced.

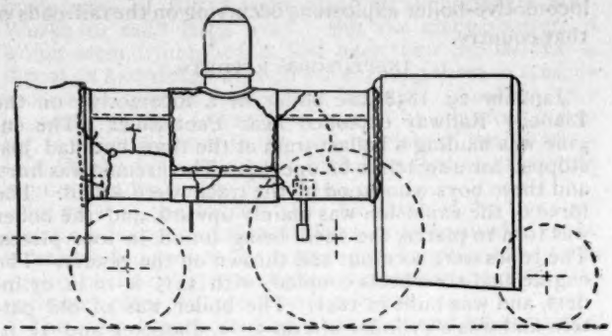
November 1, 1860, the boiler of a locomotive on the Metropolitan line exploded at the King's Cross Station. The engine was an old one; the fire-box crown-sheet gave way, and the engine was lifted up and thrown over on its side by the shock. The crown-sheet was torn away from the back and side-sheets, but remained attached to the tube-sheet. It was of copper, about 9 years old, and had been patched. In this case, as in one referred to above, the roof-stays were defective in form and really had no bearing on the side-sheets; and it was this weakness, combined with wear of the sheet, which caused the explosion.

April 1, 1861, the boiler of a locomotive on the Monmouthshire road exploded at Newport, just after the engine had stopped with a goods train. The engine was 6½ years old; it had 18 × 24-in. cylinders and six 60-in. wheels, all coupled. The boiler was of ⅜-in. iron, 51 in. diameter of barrel and 12 ft. 1 in. long. The seams in the barrel were single-riveted, the rivet-holes being countersunk about ⅛ in., reducing considerably the sectional area of the plate. The boiler had been overhauled and repaired about a year before. The effect of the explosion was to tear the leading end of the barrel away from the smoke-box and to separate two of the rings (and part of the third) from the remaining ring of the barrel, which was not detached from the fire-box. The engine remained on the rails, but the leading axle was bent and the leading wheels thrown off. The Inspector believed from his examination that the explosion took place at the ordinary working pressure, about 120 lbs.; there were no signs of overheating anywhere. No part of the boiler plates, apparently, had been reduced below $\frac{5}{16}$ in. by corrosion or wear. Careful examination of the remaining plates, however, discovered at several points cracks in the plates, near the horizontal line of rivets, of the character indicated at *a* in the accompanying sketch. The Inspector



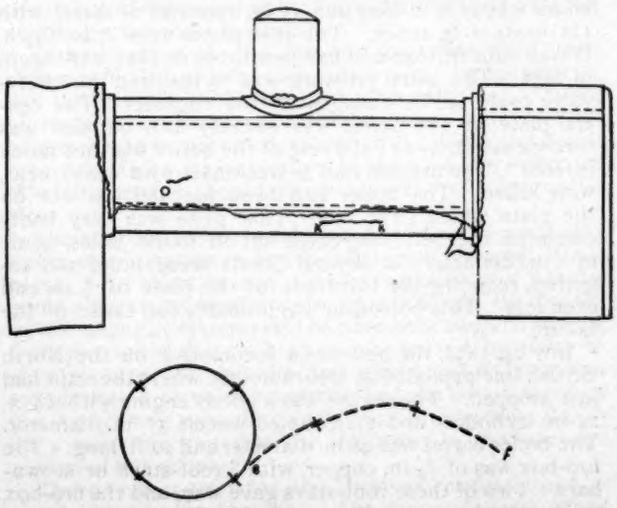
thinks that the rupture started in one of these cracks, which had so weakened the iron that it was unable longer to resist the pressure. He says: "These cracks are frequently found in old boilers, and are usually supposed to originate in the mark or indentation made by the caulking tool when incautiously held by the workman. It is quite possible that such marks may have had something to do with the origin of these cracks; but they probably result mainly from the greater rigidity of the plates at this part when opposed to the greater flexibility of the adjacent part of the boiler plates."

July 4, 1861, the boiler of the engine of an express train on the London & Northwestern road exploded when the train was near Rugby and running at the rate of 35 miles an hour. The explosion took place just as the train was passing under an arched bridge; the barrel of the boiler was torn to pieces, leaving the fire-box almost intact. Several large pieces struck the brickwork of the bridge and left deep marks in it; one piece (about 8 × 4 ft.) was found on the back of the tender. The driving-axle was broken and one driving-wheel thrown off; the frames were bent out of shape. The middle ring of the barrel was entirely separated from the other rings and was itself left in several pieces. The accompanying drawing is a sketch of the boiler, and the irregular lines show the lines of fracture, indicating how completely it went to pieces. The force of the explosion and the reaction from the side of the arch threw the engine over on its side on the opposite track, but it ran or slid forward far enough to permit the cars in the train to stop without receiving serious damage. The fireman was fatally hurt, but the engineer was not very badly injured. The engine, which was about 10 years old, had 16 × 24-in. cylinders, one pair of 7-ft. drivers, leading and trailing wheels. The boiler was 49 in. diameter of barrel and 11 ft. 9 in. long; it was of iron, the barrel plates ⅜ in. and the outer fire-box plates $\frac{7}{16}$ in. Examination of the fractured plates showed that they



were much corroded, the line of greatest weakness being just above the lower seam on the middle ring of the barrel, where the metal had been reduced in places to little over $\frac{1}{16}$ in. in thickness. The Inspector believes that the failure of the boiler was due to this corrosion, as there was no evidence of unusual pressure, and says further that the process of weakening must have been going on for some time, and that proper inspection and removal of scale would have revealed this fact. It is to be noted that this was the very unusual case of a boiler exploding while the engine was running.

September 23, 1861, the boiler of a locomotive drawing a coal train on the Northeastern Railway exploded just as the train was ready to start from Stella Gill. The driver and fireman were badly hurt, and the guard, who was on the engine, was killed. The engine was 8 years old; it had 14½ × 22-in. cylinders and six 54-in. wheels, all coupled. The boiler barrel was 42 in. diameter and 10 ft. long. It was of ⅜-in. iron, of four plates placed longitudinally, so that there were four seams running the length of the barrel, but no circumferential seams except at the ends, where it was joined to the smoke-box and the fire-box. The usual working pressure was 80 lbs., and it does not appear that this had been exceeded. The accompanying sketch shows the general form of the boiler, the



irregular lines showing the lines of fracture. The lower sketch is a section of the barrel, the dotted lines *e f* showing the position in which the plates were found after the explosion.

The Inspector says: "An examination of the remains of the barrel leaves no doubt of the cause of the explosion. Corrosive action had been going on actively for a space of about 21 in. along the plate which gave way at

about 66 in. from the smoke-box end; and the plate had been so far eaten through that in places only ⅛ in., in others $\frac{1}{16}$ in. and at one or two points even less than $\frac{1}{16}$ in. of metal remained. The plate had thus become so thin that the force of the steam was too great for it to resist; and when once the steam and water found an opening through it, the remainder was torn and the sounder portions of the plate gave way, as always happens under such circumstances, with comparatively little difficulty." In the accompanying sketch *K K* shows the line of greatest corrosion referred to above. The Inspector makes this accident the occasion for urging more frequent inspection of boilers, more care in designing and staying them, and more care in selecting the material. He suggests that the insertion riveting in of rings of angle-iron or T-iron in the barrels would contribute very much to their strength; and also that plates might be made with thickened ends, so as to secure greater strength at the seams.

(TO BE CONTINUED.)

Electrical Subways in New York.

(From the *Electrician and Electrical Engineer.*)

IT is sometimes more important to get a thing done at once than to get it done in the most perfect way. The burying of all the electric wires in New York is not such a thing. The desirability, even the necessity, of providing some better system than the existing pole lines is very generally admitted. The objections to pole lines in the streets are so many, and have been so often recited in the public press, that everybody is familiar with them. Yet all of them put together do not constitute a public inconvenience so pressing as to justify hasty work on immature plans, such as that undertaken by direction of the Board of Electrical Control.

Since the public agitation for the removal of the pole lines, followed by the establishment of the Subway Commission, we have several times expressed our opinion that the significance and scope of the proposal to put all the electric wires in the city underground was very imperfectly apprehended by the public and by the authorities undertaking to effect it. The success of electric motors during the past two years, establishing the certainty that they will be largely employed for power throughout the city, and the development during the same period of successful means for a wide distribution of the incandescent electric light from central stations, have very largely added to the magnitude and difficulty of the problem. It has become very clear that a system of underground electric conductors will be required, sufficiently comprehensive to provide facilities far in excess of the relatively simple requirements of the telegraph and telephone service. Such system must include provision for conductors of heavy currents for the supply of power and light for general distribution throughout the city. The problem seems scarcely less in magnitude and difficulty, and in its bearing upon the welfare and beauty of the city, than that of rapid passenger traffic. The inadequacy of our means of transit is apparent to every one who travels to and fro within the city; the capacities of the elevated roads are far overtaken by the requirements of the public.

We are very confident that, if the work of providing the city with a system of underground electric conductors be left to the present methods of the Board of Electrical Control (substantially the old Subway Commission) and to their direction, our last state will be worse than our first. There is yet no evidence of the adoption of a comprehensive and thoroughly worked out plan, such as should be perfected before any extensive work is undertaken. Some elements of the problem seem to have been scarcely considered—for instance, the distribution of wires from the conduits to blocks of buildings. It cannot be said that any conduit system has been shown to be capable of meeting permanently the difficulties of a system of general distribution. Of the several conduit systems approved by the Board, some may prove serviceable for a long time, but all the work must still be considered tentative.

It is our conviction that no system of "drawing-in" conduits will avail as a permanent solution of the complex and difficult problem. It seems to us more than probable that for principal routes, where many conductors of various kinds and sizes and for many different purposes must be provided for, resort must be had to some form of tunnel, large enough to contain wires and cables hung in such a way that they shall be accessible at all points, and also large enough to permit the passage through it of linemen and small trucks for conveyance of conductors. That a way to accomplish the desired end of ridding the streets of pole lines, and to place all, or nearly all, electric conductors underground with safety and convenience, and to the satisfaction of the public, as well as of the electric companies, we make no doubt; but the undertaking should have the careful attention of electrical and engineering talent of the highest order, and should be carried out under the control of those who take a long look ahead and are more anxious to achieve a great public work carefully and thoroughly, than to satisfy an unreasonable public clamor for burying all wires at once.

Underground Conductors for Electric Lighting.

[Paper read before the British Association at Manchester by Professor George Forbes, F. R. S.]

THE author has designed the proposed system to fulfill several important conditions, as follows:

1. The conductors and their insulation should be economical in construction.
2. They should be protected from injury by a trough or casing.
3. The trough should be of small cost, and its merits must have been well tested.
4. The trough must be capable of carrying conductors at several different potentials.
5. It must be possible to add gradually to the conductors, as the consumption of electricity in a district increases.
6. An easy means must be provided for taking branches from the mains into houses.
7. An easy means must be provided for leading the conductors round gas and water pipes and other obstacles,

The first condition can best be secured by having bare copper-wire conductors and air insulation.

The second and third conditions by using ordinary cast-iron gas pipes, whose qualities are thoroughly well known, and whose laying and repairing and keeping water-tight is every-day work in every town in the country.

The fourth condition is attained by having porcelain insulating discs, two in each cast-iron pipe. Each insulator has as many holes through it as there are different potentials to be maintained. These porcelain discs are supported on the iron pipes only at a few points, the intervening spaces allowing drainage in the cast-iron pipes and also permitting dry air to be forced through a system of pipes.

The fifth and sixth conditions are attained by the special peculiarity of this invention, which consists in using thin split-copper tubes with ¼-in. gap at the split. These are each 6 in. longer than one of the iron pipes. By pinching the end of one of these tubes and inserting it into the end of another, and continuing the process, a long continuous tube can be made for carrying the bare copper-wire conductors. These continuous tubes pass through the holes in the insulators. The number of copper wires can be added to as the requirements of a district increase. When two-thirds full, these wires are all withdrawn, and a bare wire cable filling the whole space of the tubes is drawn through. The wires are drawn through from manhole to manhole. A manhole is placed at each corner of a street, and serves also as a pump for pumping out accumulations of water. When it is required to connect a house to the mains, the iron pipe is drilled and tapped with a 1-in. hole. Insulated wires are soldered to the copper tubes of the required potentials, and are led to the houses through 1-in. gas-pipes which are screwed into the holes tapped in the cast-iron pipes.

It will be noticed that the split tubes do not act primarily as the conductors of the main current, but mainly as a support for the conductors, and secondarily, by contact with these, as a means of connection to the houses, leaving the wires free to be removed or added to.

The seventh condition is to provide for getting round an obstacle. This is best done by having a hand-hole at the ends of the cast-iron pipes, on each side of the obstacle, and joining these by lead-covered insulated cables of the full current-carrying capacity of the system. These cables can be bent round the obstacle, and are in no way a weak point of the system.

The method of laying the conductors in the ordinary routine is as follows: For a three-wire system for a maximum of 2,000 lamps of ¾ ampère, a 3-in. gaspipe may be used. Each insulating disc has three 1-in. holes in the positions of the angles of an equilateral triangle. In adding fresh lengths of conductor, three split tubes are first pinched at their ends and pushed into the ends of the three split tubes projecting from the last cast-iron pipe laid. Two insulators are next run along the split tubes to a distance from either end of the tubes of one-fourth of their length. A fresh cast-iron pipe is now run along over the split tubes and their insulators, the latter fitting loosely in the pipes. The joint of the pipes is made with packing in the ordinary way. A new length is added in the same way. Manholes must be placed at each corner of a street, and may be half a mile apart. The cast-iron pipes fit into side holes in these boxes, and are fitted in with water-tight cement or packing. Wires are pulled through from manhole to manhole, and may be soldered together across the manhole. Finally, holes are drilled and tapped in the cast-iron pipes beside those houses which require a supply of electricity. Two insulated wires, bared and flattened at their ends, are soldered to those split copper tubes which are of the right potentials. A 1-in. gas pipe is screwed into the hole tapped in the main pipe, and the insulated wire is thus led into the house.

A French Light Railroad.

(From *Les Annales des Travaux Publics.*)

THE Bayonne-Anglet-Biarritz Railroad, opened June 2, 1877, deserves attention, partly because it has an exceptional traffic for a local line, and partly on account of the system of operation by light trains, adopted since its opening, the service being of the kind generally called tramway-trains.

This railroad was authorized by the Council-General of the department of Basses-Pyrenees in 1874 as a railroad of local interest, under the law of July 12, 1865, and under a schedule of charges dated September 15, 1874.

The line is 5 miles long; the profile is very irregular, 38 per cent. of its total length being in grades of .014 (74 ft. to the mile) or over, and 37 per cent. in grades of from .005 to .014 (26.4 to 74 ft. to the mile). Of the total length also, 42 per cent. is in curves of from 980 to 1,960 ft. radius.

The track is of the standard gauge, although the concession authorized a gauge of one meter. The standard gauge was adopted partly because it was expected that a connection would be made with the line Du Midi, but more especially because it was thought best to use two-storied carriages of great seating capacity. This decision as to the gauge has never been regretted by the managers.

The track is of steel rails of the Vignoles pattern, weighing 50 lbs. per yard, placed upon ties spaced 26.5 in. between centers. This track was built and is maintained with great care, and it carries without trouble locomotives having a weight of 8.5 to 9 tons per axle (4.25 to 5 tons per wheel).

The rolling-stock is composed entirely of two-story carriages, and the absence of overhead bridges permits the use of these carriages of a height of 16 or 17 ft. above the rail. These carriages are of two types; the first, which can be used alone to form a train (which is often necessary in winter), has below a first-class and a second-class compartment and a baggage-room, and above one large compartment, either open or closed according to the season, to which access is had by an interior stairway; these carriages will hold 67 passengers. The other class of carriages have one compartment above and one below; they seat 92 persons. Four carriages of this kind form a train which will carry 368 passengers, or indeed many more on busy days, for people do not object to stand for a trip of less than 15 minutes. There is no freight traffic.

The motive power consists of 5 tank locomotives, of which three weigh 19 tons each in service and have four wheels coupled; the other two weigh 25 tons each and have six wheels coupled. All these engines are on the compound system, and they are the first to which this system was applied in practice. The average consumption of fuel in six years of working did not exceed 14.5 lbs. per engine-mile.

In 1885, this Bayonne-Anglet-Biarritz road carried 724,000 passengers, of whom only 35,000 were first-class; these passengers were carried in 15,956 trains. The average train-load was 49 passengers; the average seating capacity of trains was 177, so that on an average only 27.6 per cent. of the seating capacity was occupied.

The gross receipts for the same year were 74.7 cents per train-mile; the expenses were 48.25 per cent. of the gross earnings. The cost of motive power was 14.1 cents per train-mile, for an average train of three cars, fuel alone costing 3.2 cents.

This cost of motive power was almost exactly the same as on the so-called tramway-trains on the Northern Railroad, which are about of equal capacity with one carriage of the Bayonne-Biarritz road.

Smokeless Powder.

(From the London *Times.*)

MANY military writers have expressed an earnest desire that smokeless powder, capable of being used in war, should be adopted. The advantages of such a powder are obvious. Smoke is not only a great enemy in casemates, but even in the open, especially if the atmosphere be thick and heavy; the cloud of smoke resulting from the employment of the powder now in use serves equally to hide sudden attacks by the enemy and to prevent the soldier seeing at whom he is firing and the effect of his shot. A cloud of smoke also betrays the position of troops. On the other hand, smoke defines for the benefit of a general the line of his own or the enemy's troops. Indeed, if proceeding from certain important tactical points, it adds a moral to the material effect produced by the projectiles themselves. It announces the arrival of succor, and marks the progress of the different forces executing a combined operation. Finally, it aids the assailant by enabling him, especially in the last phase of an attack, to gain ground unseen, and to be under cover from view is the next best thing to being under cover from fire. On the whole, however, a diminution of smoke is looked on as an advantage. The Schulze and the E. C. powders have this merit, but, on the other hand, their propelling power is said to be uncertain. At all events, neither of them seem to have found favor with the authorities.

A third description of so-called smokeless powder has been more fortunate as regards the good opinion of the War Office. This powder is named the Johnson-Barland powder, or for short, the J.-B. powder. Last December there was an official trial of this powder at Enfield, and a favorable report was made to the War Office. Both the Martini-Henri and the Martini-Enfield were tried on that occasion with the following results: The Government powder, 85 grains, gave with the Martini-Henri a muzzle velocity of 1,314 ft. per second, with the J.-B. powder, 60 grains, one of 1,520 ft. per second. With the Martini-Enfield the Government powder gave a muzzle velocity of 1,570 ft. per second, with the J.-B. powder one of 1,800 ft. per second.

Trials were recently made with an improved Gardner rifle-caliber machine gun; these showed that the new powder works with very little sound and very much less fouling than the ordinary powder, supporting the claims made to that extent.

The Yanegase-Yama Tunnel in Japan.

[Abstract of paper read before the British Institution of Civil Engineers, by Kinske Hasegawa, Associate Member.]

THE Tsuruga-Nagahama Railroad is a branch line, connecting the north coast of Japan with the main trunk railroad at Nagahama; it is about 27 miles long, and extends for the greater portion of its length through a flat, well-cultivated country, with favorable curves and gradients. At Yanegase, however, about 9 miles from the coast of Tsuruga, it enters a mountainous and difficult region; here a range of mountains, running from the coast of Yechizan on the north to Lake Biwa on the south, has to be crossed, and here the tunnel about to be described has been constructed. After passing through this tunnel, the line descends through a narrow gorge between the spurs of the mountains, with heavy earthworks and short tunnels, for 3 miles; it then emerges into a fertile plain, and finally terminates with a breakwater in the deep and sheltered harbor of Tsuruga.

The Yanegase-Yama tunnel commences at the summit level of the railroad, 751 ft. above sea-level and 788 ft. below the crest of the hill through which it is pierced; it runs in a direction east and west and is 4,436 ft. long; it is straight for the greater part of its length and on a curve of 990 ft. radius for a short distance at its western end; the grade throughout is 1 in 40. The work was begun in June, 1880, at the west end, and in May, 1883, at the east end; from the latter date the headings were carried forward from both ends simultaneously. The tunnel was completed March 30, 1884.

The finished section of the tunnel is 14 ft. wide at springing, with semicircular brick arch of 7 ft. radius; it is 15 ft. 6 in. high, with curved masonry side walls, 10 ft. wide at formation level, and has a central drain 1 ft. 6 in. wide and 2 ft. deep, the total sectional area being 185.58 square ft.

Trial lines were first run in February, 1880, and the line was finally decided on and ranged out in the following April, the instruments used being an ordinary 6-in. theodolite and dumpy-level. The line was ranged over the summit of the mountain, and the levels were carried round by a narrow mountain track skirting its edge at a distance of about 1½ miles in a southeastern direction, and finally the mountain itself was leveled over. The line was ranged out from fixed points. Masonry platforms, 4 ft. square, were built at these points, with centers marked thereon; the distances were carefully measured, both with steel chains and measuring rods, and were finally checked by a system of triangulation. During construction, the center-line was carefully checked through the workings twice a month, ranging being always commenced from the fixed points at the entrances, and the levels checked, permanent bench-marks being made in the side walls as the work proceeded.

The strata pierced through were much broken up and distorted, and were generally inclined at an angle of about 45° and dipping with the same inclination. Some portions of the rock were exceedingly hard, others were decomposed and intermixed with numerous thin clay veins containing much water.

The total length of 4,436 ft. may be subdivided as follows:

	Feet.
Wet clay and gravel	782
Moderately hard rock and thin clay veins	350
Very hard rock	230
" " " with thin clay veins	54
Decomposed rock	3,020
Total	4,436

Some portions of the ground were very wet. Excavation was carried out in the usual manner. The working hours were three shifts of eight hours, but in very wet places the shifts were increased to four of six hours. Powder was the explosive first used; in September, 1880, dynamite was introduced. Explosives were never allowed to be taken into the workings, except in small quantities as required, and then only by men expressly appointed to take charge of them; and they were only given out on the order of the foreman in charge. The timbering was composed of green Matsu (pine), the poling boards being 1½ in. thick by 9 to 12 in. broad. Some trouble was experienced from the timbers being attacked by insects, but carbolic acid injected into the holes made by them completely checked their ravages. The tunnel, as before remarked, is on a sharp curve at the west end, and for the purpose of securing accuracy in the long straight portion the west entrance was taken out at a tangent to the curve. The size of the headings varied from 7 ft. by 7 ft. to 8 ft. by 9 ft., depending a good deal on the nature of the stuff worked through. In driving the heading through rock, generally three or four holes were drilled, 2 or 3 ft. deep, and ½ to ¾ lb. of dynamite was placed in each; this usually loosened the rock to the full depth of the holes, but in some places the rock was so hard that the dynamite so distributed had no effect, and a larger number of holes had to be drilled; even then only 6 to 9 in. could be got out in 24 hours, and as many as 30 or 40 drills were worn out in the process of drilling them. In driving the heading through soft, wet strata, it was usual to raise the roof from 2 to 3 ft., as it got pressed down during the operation of changing the timber supports.

When much water was met with, it brought out large quantities of gravel and clay with it, hollowing out the roof. This was prevented by close poling covered with mats or straw, which permitted the water to pass through but held back the gravel and clay.

Moderately hard rock was excavated by pick or chisel, blasting being only occasionally resorted to. In one length of about 185 ft. where thin veins of clay were interspersed, the volume of water was so great as to fill up a length of 11 ft. of the heading with the rubbish brought in with it, causing a delay of three days; and at various other points in the hard rock, owing to the inrush of water, much difficulty was experienced in drilling and charging the holes for blasting. Two lines of railroad of 2-ft. gauge were laid down for removing and for bringing in materials.

When the heading had been driven about 300 ft., the ventilation became very bad; to improve it and create a current of air, advantage was taken of a stream of water coming down the hill. Two conical timber troughs were provided; one of them, with the larger end uppermost, was placed under the fall, and a trough from near the smaller end led into the workings, up which the falling water forced a current of fresh air; the second, with the smaller end uppermost under the fall, drew out the foul air through another tube. However, constant trouble and interruption occurred through the timber tubes being knocked about and leaking; tin tubes were then substituted, and this arrangement answered pretty well until a distance of about 1,440 ft. from the entrance was reached, when ventilation again became very deficient, causing frequent stoppages. A blower 3 ft. in diameter was then adopted, driven by a water-wheel 12 ft. in diameter and connected with the advanced works by cast-iron and tin pipes. This answered tolerably well for a time, but after about 5 months the air became bad again. The next appliance used was an air-compressor and turbine; from the time this was put to work there was not much trouble with the ventilation.

Ingersoll rock-drills were used to a limited extent; they were found very satisfactory in hard, compact rock, but this was rare in the tunnel, the rock being generally broken up or interspersed with thin clay veins, and the powerful percussion of these drills so shook the rock that holes could not be drilled by them.

The total cost of the tunnel was 449,457 yen, that is, about $368,000, being about $83 per lineal foot.

The principal materials used in the construction were:

Bricks, number	2,704,640
Cement (Portland, Fukugawa and Selenitic)	705 tons
Lime	2,522 cub. ft.
Sand	90,288 cub. ft.
Stone	103,000 cub. ft.

The original paper is illustrated with numerous sketches showing the progress of the work and other interesting features.

CATECHISM OF THE LOCOMOTIVE.

(*Revised and enlarged.*)

By M. N. Forney.

(Copyright, 1887, by M. N. Forney.)

CHAPTER V.

THE EXPANSIVE ACTION OF STEAM.

Question 80. *How is the expansive action of steam referred to in the answer to question 40 utilized in steam engines?*

Answer. The valve and its movement are so arranged that the steam-ports, through which steam is admitted to the cylinder, are each open during a portion only of the stroke of the piston. When it has moved through a part of its stroke, the port through which steam is entering the cylinder is closed, without allowing the steam which has been admitted to the cylinder to escape, until the piston has nearly reached the end of its stroke. Consequently when the steam is thus enclosed, or "cut-off" as it is termed, its expansive action continues to exert a diminishing pressure against the piston until the exhaust port is opened. Thus, in fig. 20, it will be seen that the valve has nearly closed the steam-port, although the piston has not yet reached the end of its stroke. Fig. 34 shows the valve on an enlarged scale in the position it occupies when the steam-port *c* is first closed; and in fig. 35 the valve is represented after it has moved far enough to begin to open communication from the steam-port *c* to the exhaust-port *g* as indicated by

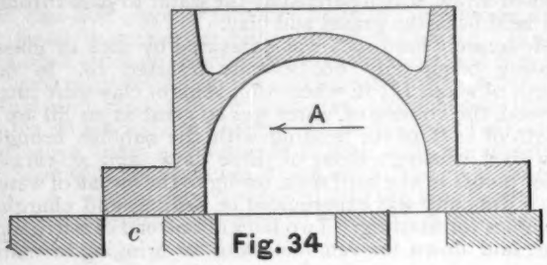


Fig. 34

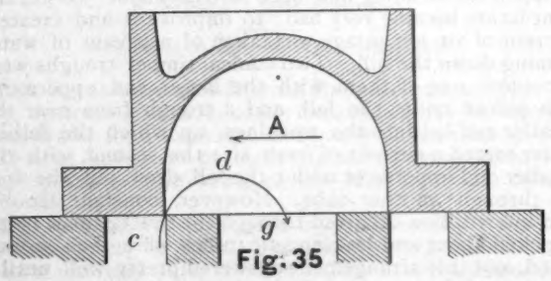


Fig. 35

the dart *d*. While the valve is moving from the position in which it is shown in fig. 34 to that represented in fig. 35, it is evident that the steam-port *c* is covered by the valve, and therefore during that period the steam is confined in the front end of the cylinder and expands as the piston advances. It thus exerts a pressure on the piston after the steam-port is closed. As the piston advances, and the space or volume occupied by the steam in the cylinder is increased, the pressure of the steam is reduced as was explained in answer to question 42.

Question 81. *How can we know how much pressure is exerted by the steam during expansion?*

Answer. As long ago as the year 1662 Robert Boyle, from experiments "touching the spring of air," discovered the law that "*the pressure of a portion of gas at a constant temperature varies inversely as the space it occupies;*" or, as stated in answer to question 42, *they are inversely proportional to each other.* Thus, suppose we have a long cylinder, *A*, fig. 36, with a piston, *a*, and that the space below the piston is filled with air of 15 lbs. absolute pressure per square inch—if we press the piston down so that the space below it will be only one-half that below *a*, as shown in cylinder *B*, then the pressure of the air will be 30 lbs. per square inch or *double* what it was in *A*. Or if the space below the piston *e* in the cylinder *E* is filled with air of 100 lbs. absolute pressure per square inch, and we allow the piston to rise, as shown in cylinder *C*, so that the space below it will be double what it is in *E*, then the pressure of the air will be 50 lbs. per square inch or *one-half* what it was in *E*. The same principle is illustrated by the cylinders *I* and *E*. The space below the piston *i* is full of air of 200 lbs. pressure, and if it is allowed to expand to double the volume, as shown in *E*, the pressure will be halved; or conversely if the piston *i* is pressed down so that the space below it has only half the original volume, as shown in *I*, then the pressure of the air will be doubled.

Question 82. *How may the action of this law be illustrated for any range of pressure?*

Answer. It may be represented graphically if we will first draw a line, *f K*, fig. 36, and divide it into equal divisions, to any convenient scale, to represent absolute pressure per square inch of steam as indicated by the figures above the line. Next a vertical line, 15 *a*, should be drawn from the division representing 15 lbs. pressure, and this line should be made the axis or center line of the cylinder *A*. Then let the space below the piston *a* represent to any convenient scale the volume occupied by any given quantity of air of 15 lbs. pressure. If, now, other cylinders *B*, *C*, *D*, *E*, *F*, *G*, *H* and *I* be drawn with vertical lines erected from the divisions indicating 30, 50, 75, 100, 125, 150, 175 and 200 pressure for their axes, and the spaces below their pistons be made to represent the volumes of air of 30, 50, 75, etc., lbs. pressure per square inch, the positions of these pistons above the line *f K* will represent to the eye the relative volume of the air of the different pressures. Further, if we draw a curved line, *a b c d e f g h i*, through the pistons, its vertical distance above the line *f K* at any given point will represent the *volume* of air of the pressure indicated by that point. Thus, the length of the dotted line 40 *m* represents the relative volume of air at 40 lbs. pressure, compared with that of 15 lbs. shown by the line 15 *a*.

Question 83. *How may the pressure of air of different volumes be represented?*

Answer. If a vertical line, *a p*, fig. 37, be drawn equal to *a* 15 of fig. 36, and the vertical positions of the pistons *a*, *b*, *c*, etc., in the cylinders *A*, *B*, *C*, etc., be represented by the horizontal lines *a a'*, *b b'*, *c c'*, etc., and we lay off to any convenient scale a distance *a a'*=15, *b b'*=30, *c c'*=50, etc., and draw a curve *a' b' c' —i'* through the extremities of these lines, then the horizontal dis-

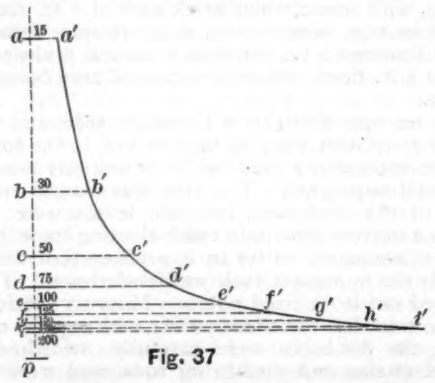


Fig. 37

tance of this curve from any point of the line *a p* will represent the pressure of air of a volume indicated by the position of the point on *a p*. It will be understood that the distance *a p* represents the volume of air at 15 lbs. pressure, and that the distance *b p* represents its volume when the piston has been pushed down from *a* to *b*. So the distance from *p* to *c d e*, etc., represents the volume of the air when the piston has been forced down to these points.

Question 84. *Do all gases act in conformity with Boyle's law?*

Answer. All of what are known as fixed gases—that is, those which cannot be readily liquefied by cold or pressure—with slight variations, act in accordance with this law, but steam and some other gases, which can be condensed easily, vary somewhat from it, as was explained in answer to question 45. Some of the reasons for this variation are not yet thoroughly understood, and the explanation of those which are would require the use of mathematics, and the explanation of abstruse scientific principles which would be out of place in an elementary book like this. For the present these variations may be disregarded, as all that is aimed at is to give a general idea of the nature of the law which governs the volume and pressure of gases.

Question 85. *How can the relation existing between the heat, pressure and volume of steam be shown?*

Answer. The table which is published on page 574 gives the pressure, the temperature, the total heat, the weight and the relative volume of steam compared with the water from which it was raised, and a study of this table will give an idea of the relation referred to. But as it is difficult to get a clear conception of a general law from so many figures, we will illustrate

it by the diagram, fig. 36. Let it be supposed that each of the cylinders represented there is drawn to a scale of ⅛ in.—1 foot and that they are 18¾ in. in diameter. These pistons, therefore, have an area of 276 square inches. It will be supposed further that a pound of water which has a volume of 27.6 cubic inches is put into each cylinder. This would occupy a space in the bottom of the cylinders only one-tenth of an inch thick. On the scale to which the diagram is drawn it is impossible to represent the volume of the water. It would be less than the space between the dotted lines below the piston. From what has been said, though, an idea can be formed of the small amount of space, comparatively, which the water would occupy in the cylinders. If heat is now applied to the bottom of the cylinder *A*, so as to convert the water in it into steam, it will push the piston *a* upward against the pressure of the atmosphere; and if the piston had no weight, the steam would occupy a space 1,610 times as great as that of the water. The space below the piston, which is shaded with dotted lines, is supposed to represent the volume of the steam and is drawn to a scale so that, if the reader has a clear conception of the space which the water occupied in the cylinder, the shaded area below *a* will show him the relative volumes of the water and the steam generated from it.

If we put a weight, *W*, on top of the rod *P*, connected to the piston *b*, equal to 15 × 276=4,140 lbs., with the pressure of the atmosphere it will produce a pressure downward equal to an upward pressure below the piston of 30 lbs. per square inch. If under these conditions the water in the cylinder was converted into steam, it will raise the piston up so that the steam will occupy a space 838 times or a little more than half as much as it would occupy with only 15 lbs. pressure. In the same way the pistons *c*, *d*, *e*, *f*, *g*, *h* and *i* are each supposed to be loaded, so that the pressure required to raise them will be 50, 75, 100, 125, 150, 175 and 200 lbs. per square inch respectively. The spaces occupied by the steam would then be 518, 353, 270, 219, 184, 159 and 141 times that of the water. The shaded areas below the pistons represent the volume of 1 lb. of steam of the pressures indicated. The curve *a b c—i* drawn through the pistons will then represent the relative volumes of steam of different pressures just as it did of air already described. The slight difference in the volumes of air and steam due to temperature and other causes may for the present be disregarded. The diagram, fig. 37, shows the pressure of steam of different volumes just as it does of air, which has been explained.

QUESTION 86. *How is the temperature of the water and the total heat of steam shown in the diagram?*

Answer. To show this, vertical lines 15 1, 30 2, 50 3, etc., are drawn from the points on the horizontal line *J K* which represent 15, 30, 50 lbs. pressure. On these lines distances 15 1', 30 2', 50 3', etc., are laid off in a scale of $\frac{1}{16}$ in.—100 degrees, to represent the temperature at which water boils at the pressure indicated by the figures on the line *J K*. A curve, 1' 2' 3'—9', is then drawn through these points, and its vertical distance from any point in the line *J K* represents the temperature of water corresponding with the pressure of steam indicated by that point on *J K*.

It has already been explained in the answer to question 62 that after water is heated up to the boiling point that an additional amount of heat must be imported to it to convert it into steam. This, with that which is required to heat the water, is called the "total heat" of steam. In the table this heat is given in degrees. It was supposed that 1 lb. of water was put into each of the cylinders and that it was converted into steam of the pressures indicated by the figures at the lower part of the cylinders. The boiling temperature of the water

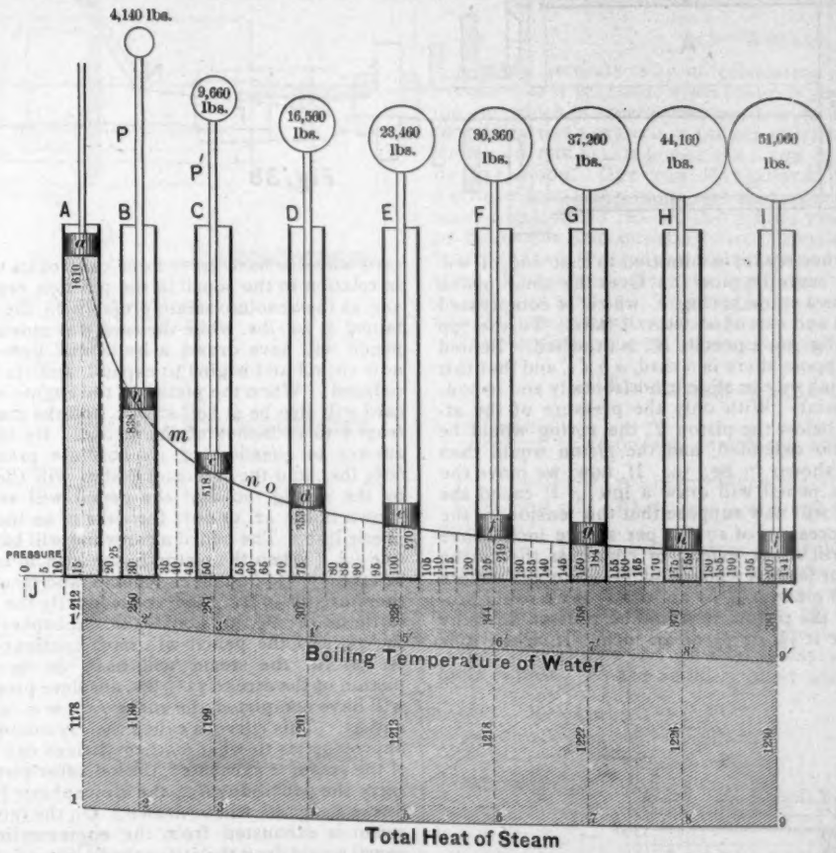


Fig. 35

therefore represents units of heat. If we extend the vertical lines below *J K* and lay off on 15 1, 30 2, 50 3, etc., the number of degrees of total heat—to the same scale as before—required to convert the water into steam, and draw a curve through the extremities 1 2 3—9 its vertical distance below *J K* will represent the total units of heat required to convert 1 lb. of water into steam of the pressure indicated on *J K*. The area below *J K* and the curve 1 2 3—9 is shaded with lines in one direction only, while that between *J K* and 1', 2', 3'—9' is shaded with cross lines. These shaded areas convey a clear idea to the mind of the *quantity* of heat in a pound of steam of different pressures.

QUESTION 87. *What is the relative quantity of heat required to convert a given weight of water into steam of different pressures?*

Answer. The number of degrees or units of heat required to boil 1 lb. of water under the pressures indicated is given in figures on the vertical lines 15 1', 25 2', 50 3', etc., and the total units of heat required to evaporate the same quantity of water from zero is given on the lines 1' 1, 2' 2, 3' 3, etc. From these figures and also from the shape of the curve, it will be seen that it requires 169 more units of heat to make water boil under a pressure of 200 lbs. than is required with atmospheric pressure of 15 lbs. Somewhat less heat is needed, though, to convert

boiling water into steam, as the pressure increases. It will also be noticed that the total heat is very little more for the high pressures than for that of the atmosphere.

QUESTION 88. *How can we determine by experiment the pressure of the steam in the cylinder at all points of the stroke of the piston?*

Answer. By the use of an instrument made for that purpose, called an *indicator*. Its action can be best explained by supposing that we have a small cylinder, *C*, with a piston, *T*, fig. 38 (shown on an enlarged scale in fig. 39), and that the cylinder is connected by a pipe, *U*, to the front end *f* of the

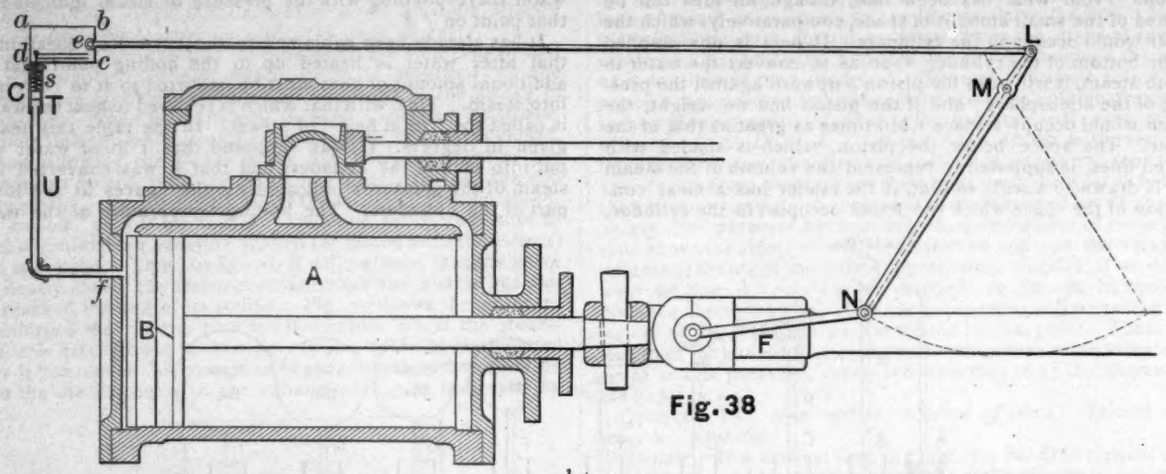


Fig. 38

cylinder *A*, so that when steam is admitted to that end, it will be conducted to *C* through the pipe *U*. Over the small piston *T* and attached to it is a spiral spring, *s*, which is compressed when the piston rises and extended when it falls. To the top of the piston-rod *T*, fig. 39, a pencil, *W*, is attached. Behind this pencil we will suppose there is a card, *a b d c*, and that this card is so arranged that we can slide it horizontally and in contact with the pencil point. With only the pressure of the atmosphere above and below the piston *T*, the spring would be neither compressed nor extended, and the piston would then stand in the position shown in fig. 39. If, now, we move the card horizontally, the pencil will draw a line, *g h*, called the *atmospheric line*. We will now suppose that the tension of the spring is such that a pressure of 10 lbs. per square inch above or below the piston will either extend or compress the spring ¼ inch. In other words, every pound of pressure per square inch in the piston will move it $\frac{1}{40}$ of an inch. If we could produce a vacuum under the piston, it would be pressed down by the atmosphere above it $\frac{1}{40}$, or ⅜ of an inch. If, when it is

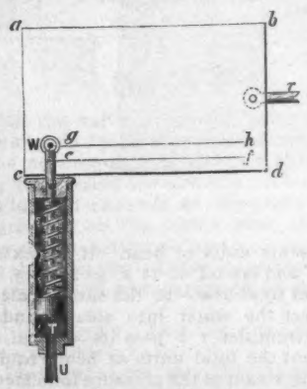


Fig. 39.

thus depressed, we again slide the card along in contact with the pencil-point, it will draw another line, *e f*, called the *vacuum-line*. Assuming that we have drawn these two lines, and that the piston and card are in the position shown in figs. 38 and 39, we will then suppose that a reciprocating motion can be given to the card by the lever *L M N*, fig. 38, which is pivoted at *M* and attached at *N* to the cross-head by a short connecting-rod, *F*. It is obvious that by connecting the upper end *L* of the lever with a rod, *e L*, to the card *a b c d*, the latter will be moved backwards and forwards by the motion of the piston *B*, and that the motion of the card will be simultaneous with that of the piston, but of course of shorter stroke. We will assume that the stroke of the card is equal to the length of the atmospheric and vacuum lines *g h* and *e f*, fig. 39. If, now, the piston being at the beginning of the stroke as shown in fig. 38 we admit steam of 85 lbs. effective pressure per square inch (which is equal to 100 lbs. absolute pressure) into the cylinder *A*, it will be conveyed through the pipe *f U* to the cylinder *C* and will force up the piston $\frac{85}{40}$ or 2⅛ inches above the atmospheric line, or $\frac{100}{40}$ or 2½ inches above the vacuum line, as shown in fig. 40, and the pencil will draw a vertical line, *g i*, on the card (represented by a dotted line in fig. 40). We will suppose further that steam is admitted during 8 inches of the stroke and is then cut off. When the piston *B*, fig. 38, has moved that distance, which is one-third of its stroke, the card will also have moved one-third of its stroke, and will stand in relation to the pencil in the position represented in fig. 41, and as the absolute steam pressure in the cylinder was maintained at 100 lbs. while the card was moving that distance, the pencil will have drawn a horizontal line, *i j*. The steam is now cut off and begins to expand, and its pressure is thereby reduced. When the piston of the engine is at half-stroke, the card will also be at half-stroke, and the steam will be expanded from 8 to 12 inches of the stroke. By the rule given in the answer to question 39, its absolute pressure would then be 66⅔ lbs., and the indicator-piston will then be pressed down by the spring, so that the pencil will stand in the position shown in fig. 42, or 66⅔ fortieths of an inch above the atmospheric line. The pencil meanwhile will have drawn the curved line *j k*. When the piston has moved 16 inches, the steam will be expanded to double its volume, and its absolute pressure will therefore be 50 lbs., and consequently the pencil will stand 50 fortieths or 1¼ in. above the atmospheric line as shown in fig. 43, and the pencil will have continued the curve *j k* to *l*. At 20 in. the steam will have 40 lbs., and at the completion of the stroke 33⅓ lbs. absolute pressure, and the pencil will have completed the curve *j k l m n*, as shown in figs. 44 and 45. This curve is called the *expansion curve*, and its form approximates to what mathematicians call a hyperbolic curve. If the steam is exhausted, the indicator-piston will descend and carry the pencil down to the atmospheric line, and the vertical line *n h*, fig. 46, will be drawn. On the return stroke, after the steam is exhausted from the engine cylinder *A*, fig. 38, the pencil would draw the atmospheric line *g h*, fig. 46, thus showing that there is no steam pressure under the piston.

Such a diagram is called an *indicator diagram*.* In practice there are a great many influences which modify it, such as condensation, performance of work, imperfection of valve gear, etc., but for the present these are disregarded.

QUESTION 89. *How can we ascertain the pressure of the steam for any point of the stroke from such a diagram?*

Answer. By measuring the vertical distance of the expansion curve (fig. 46) from the vacuum or the atmospheric line, as for example 8 *j*, 12 *k*, 16 *l*, 20 *m*. As the indicator spring is extended or compressed one-fortieth of an inch† for every pound of pressure per square inch, either above or below the indicator piston, if we construct a scale, *S S*, fig. 46, divided into divisions of one-fortieth of an inch each, one of them will represent one pound of pressure per square inch if measured vertically from the atmospheric or vacuum line. If we subdivide the vacuum line with the same number of parts as there are inches in the stroke of the piston (see fig. 47) we can draw

*The indicator used in practice, to show the action of the steam in the cylinders of steam engines, differs essentially in its construction from that which we have described. The principles of operation are, however, the same in both. We will explain the construction of an indicator hereafter.

† Indicator springs are used of various degrees of tension, in proportion to the steam pressure to be indicated.

vertical lines from these points and thus determine the pressure by comparing the length of such lines with the scale *S S*. Thus the line 8 *j* measures 100 fortieths of an inch, thus showing that the absolute steam pressure at 8 inches of the stroke was 100 lbs. per square inch; the line 12 *k* measures 66⅔ fortieths of an inch, thus showing that at 12 in. of the stroke the steam pressure was 66⅔ lbs. At 16, 20 and 24 in. of the stroke the vertical lines measure 50, 40 and 33⅓ fortieths; and, therefore, there were that number of pounds of steam pressure when the piston was at the point of the stroke named. Similar measurements could be made from other points, such as 2, 6, 10, or any other number of inches of the stroke. Of course, if we measure from the vacuum line we will have the

Fig. 40

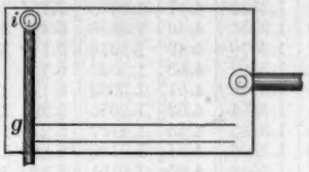


Fig. 41

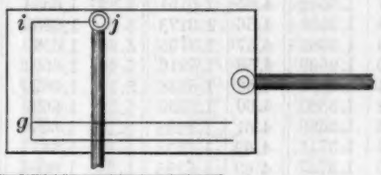


Fig. 42

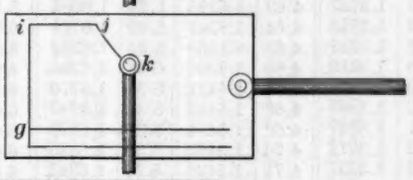


Fig. 43

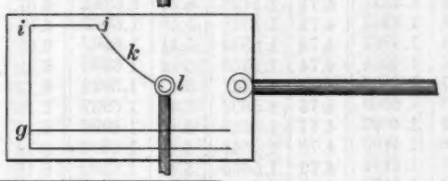


Fig. 44

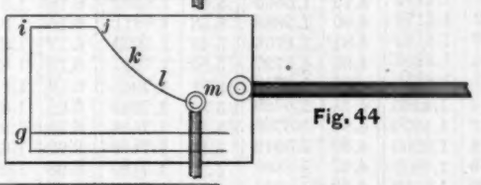


Fig. 45

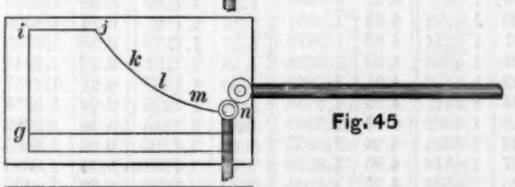
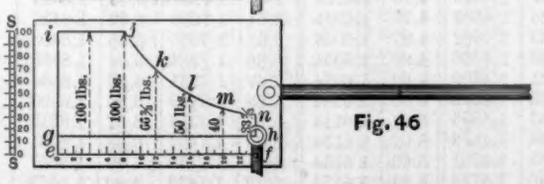


Fig. 46



absolute steam pressure, or the pressure *above a vacuum*, as it is sometimes called; if we measure from the atmospheric line we will have the effective pressure, or the *pressure above the atmosphere*.

QUESTION 90. *How can we determine the average pressure during the whole stroke of steam which works expansively?*

Answer. This can be determined approximately by the following method: In the first place, divide the vacuum line (fig. 47) into any number of equal divisions, say six. From the points of division, 4, 8, 12, 16 and 20, which in this case correspond with the points which represent inches of the stroke, draw perpendicular lines, which will divide the indicator diagram into six divisions. It is obvious that during the time the steam is working full stroke the pressure is uniformly 100 lbs. absolute. While the piston is moving from 8 to 12 in., the pressure falls from 100 to 66⅔ lbs., so that at 10 in. we have very nearly the average pressure during the period named. So from 12 to 16, 16 to 20 and 20 to 24 the average is nearly 57.1, 44.4 and 36.3 lbs., respectively. NOW, BY ADDING TOGETHER THE PRESSURES IN THE MIDDLE OF EACH ONE OF A NUMBER OF EQUAL DIVISIONS OF THE STROKE AND DIVIDING BY THE NUMBER OF DIVISIONS, WE WILL OBTAIN APPROXIMATELY THE AVERAGE ABSOLUTE PRESSURE DURING THE WHOLE STROKE. TO GET THE AVERAGE EFFECTIVE PRESSURE, DEDUCT THE ATMOSPHERIC PRESSURE FROM THE RESULT. The calculation would in the above case be as follows:

100 lbs.
100 "
80 "
57.1
44.4
36.3

6)417.8

69.6 = Average absolute pressure.
15

54.6 = Average effective pressure.

A more accurate way of calculating the average or mean pressure, as it is called, when steam is used expansively, and the one which is usually employed, is to DIVIDE THE LENGTH OF THE PISTON'S STROKE IN INCHES BY THE NUMBER OF INCHES AT WHICH THE STEAM IS CUT OFF: THE QUOTIENT IS THE RATIO OF EXPANSION. GET THE HYPERBOLIC LOGARITHM OF THE RATIO OF EXPANSION FROM THE TABLE OF LOGARITHMS (on another page), ADD 1 TO IT, AND DIVIDE THE SUM BY THE RATIO OF EXPANSION AND MULTIPLY THE QUOTIENT BY THE MEAN ABSOLUTE STEAM PRESSURE IN THE CYLINDER DURING ITS ADMISSION. THE RESULT WILL BE THE MEAN ABSOLUTE PRESSURE DURING THE STROKE. TO GET THE MEAN EFFECTIVE PRESSURE, DEDUCT ATMOSPHERIC PRESSURE.

The calculation for the above example would be as follows:

$$\frac{24}{8} = 3 = \text{Ratio of expansion.}$$

$$\frac{1.0986 + 1}{3} \times 100 = 69.95 = \text{Mean absolute pressure.}$$

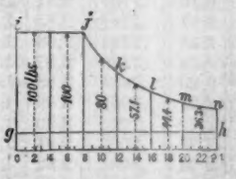
$$69.95 - 15 = 54.95 = \text{Mean effective pressure.}$$

QUESTION 91. *What advantages result from using steam expansively?*

Answer. The most important one is that considerably more work can be done with a given amount of fuel if the steam generated thereby is worked expansively than if it is not.

This is shown by the diagram, Fig. 36, in which a pound of water is supposed to be converted into steam of 15 lbs. pressure in the cylinder *A*. As already explained this takes 1,178 units of heat. By the addition of 52 units, or a little over 4

Fig. 47.



per cent. more, the water would have been converted into steam of 200 lbs. pressure as shown in the cylinder *I*. At this pressure, if allowed to act expansively, it would do a much larger amount of work than a pound of steam of 15 lbs. pressure, and, as has been pointed out, very little more heat is required to convert a given weight of water in steam of high pressure than is needed to produce steam of a low pressure.

Next, the pressure exerted on the crank is equalized by expansive action, and lastly, the strain and shocks to the mechanism which are produced by the rapid motion of the piston and other reciprocating and revolving parts of the engine are very much diminisbed by allowing the steam to expand, and thus become reduced in pressure during the latter part of the stroke.

QUESTION 92. *How is fuel saved by using steam expansively?*

Answer. By utilizing its capacity to expand to do work. This energy, which steam can exert by expanding, would be lost if the steam escaped from the cylinder at the pressure that it entered it. This can be illustrated by the diagram, fig. 47, in which steam is supposed to be admitted during one-fourth of the stroke of the piston at a working pressure of 85 lbs. The average effective pressure during the whole stroke, it was shown, was 54.95 lbs. This pressure acting on a piston of 16

TABLE OF HYPERBOLIC LOGARITHMS.

Num.	Logarithms.	Num.	Logarithms.	Num.	Logarithms.	Num.	Logarithms.	Num.	Logarithms.	Num.	Logarithms.	Num.	Logarithms.	Num.	Logarithms.
1.01	.0099	1.69	.5247	2.37	.8628	3.05	1.1151	3.73	1.3164	4.41	1.4838	5.09	1.6272	5.77	1.7526
1.02	.0198	1.70	.5306	2.38	.8671	3.06	1.1184	3.74	1.3190	4.42	1.4838	5.10	1.6292	5.78	1.7544
1.03	.0295	1.71	.5364	2.39	.8712	3.07	1.1216	3.75	1.3217	4.43	1.4883	5.11	1.6311	5.79	1.7561
1.04	.0392	1.72	.5423	2.40	.8754	3.08	1.1249	3.76	1.3244	4.44	1.4906	5.12	1.6331	5.80	1.7578
1.05	.0487	1.73	.5481	2.41	.8796	3.09	1.1281	3.77	1.3271	4.45	1.4929	5.13	1.6351	5.81	1.7595
1.06	.0582	1.74	.5538	2.42	.8837	3.10	1.1314	3.78	1.3297	4.46	1.4914	5.14	1.6370	5.82	1.7613
1.07	.0676	1.75	.5596	2.43	.8878	3.11	1.1346	3.79	1.3323	4.47	1.4973	5.15	1.6389	5.83	1.7630
1.08	.0769	1.76	.5653	2.44	.8919	3.12	1.1378	3.80	1.3350	4.48	1.4996	5.16	1.6409	5.84	1.7647
1.09	.0861	1.77	.5709	2.45	.8960	3.13	1.1410	3.81	1.3376	4.49	1.5018	5.17	1.6428	5.85	1.7664
1.10	.0953	1.78	.5766	2.46	.9001	3.14	1.1442	3.82	1.3402	4.50	1.5040	5.18	1 6448	5.86	1.7681
1.11	.1043	1.79	.5822	2.47	.9042	3.15	1.1474	3.83	1.3428	4.51	1.5062	5.19	1.6463	5.87	1.7698
1.12	.1133	1.80	.5877	2.48	.9082	3.16	1.1505	3.84	1.3454	4.52	1.5085	5.20	1.6486	5.88	1.7715
1.13	.1222	1.81	.5933	2.49	.9122	3.17	1.1537	3.85	1.3480	4.53	1.5107	5.21	1.6505	5.89	1.7732
1.14	.1310	1.82	.5988	2.50	.9162	3.18	1.1568	3.86	1.3506	4.54	1.5129	5.22	1.6524	5.90	1.7749
1.15	.1397	1.83	.6043	2.51	.9202	3.19	1.1600	3.87	1.3532	4.55	1.5151	5.23	1.6544	5.91	1.7766
1.16	.1484	1.84	.6097	2.52	.9242	3.20	1.1631	3.88	1.3558	4.56	1.5173	5.24	1.6563	5.92	1.7783
1.17	.1570	1.85	.6151	2.53	.9282	3.21	1.1662	3.89	1.3584	4.57	1.5195	5.25	1.6582	5.93	1.7800
1.18	.1655	1.86	.6205	2.54	.9321	3.22	1.1693	3.90	1.3609	4.58	1.5216	5.26	1.6601	5.94	1.7817
1.19	.1739	1.87	.6259	2.55	.9360	3.23	1.1724	3.91	1.3635	4.59	1.5238	5.27	1.6620	5.95	1.7833
1.20	.1823	1.88	.6312	2.56	.9400	3.24	1.1755	3.92	1.3660	4.60	1.5260	5.28	1 6639	5.96	1.7850
1.21	.1962	1.89	.6365	2.57	.9439	3.25	1.1786	3.93	1.3686	4.61	1.5282	5.29	1.6658	5.97	1.7867
1.22	.1988	1.90	.6418	2.58	.9477	3.26	1.1817	3.94	1.3711	4.62	1.5303	5.30	1.6677	5.98	1.7884
1.23	.2070	1.91	.6471	2.59	.9516	3.27	1.1847	3.95	1.3737	4.63	1.5325	5.31	1.6695	5.99	1.7900
1.24	.2151	1.92	.6523	2.60	.9555	3.28	1.1878	3.96	1.3726	4.64	1.5347	5.32	1.6714	6.00	1.7917
1.25	.2231	1.93	.6575	2.61	.9593	3.29	1.1908	3.97	1.3787	4.65	1.5368	5.33	1.6733	6.01	1.7934
1.26	.2341	1.94	.6626	2.62	.9631	3.30	1.1939	3.98	1.3812	4.66	1.5390	5.34	1.6752	6.02	1.7950
1.27	.2390	1.95	.6678	2.63	.9669	3.31	1.1969	3.99	1.3857	4.67	1.5411	5.35	1.6770	6.03	1 7967
1.28	.2468	1.96	.6729	2.64	.9707	3.32	1.1999	4.00	1.3862	4.68	1.5432	5.36	1.6789	6.04	1.7984
1.29	.2546	1.97	.6780	2.65	.9745	3.33	1.2029	4.01	1.3887	4.69	1.5454	5.37	1.6808	6.05	1.8000
1.30	.2623	1.98	.6830	2.66	.9783	3.34	1.2059	4.02	1.3912	4.70	1.5475	5.38	1.6826	6.06	1.8017
1.31	.2700	1.99	.6881	2.67	.9820	3.35	1.2089	4.03	1.3937	4.71	1.5496	5.39	1.6845	6.07	1.8033
1.32	.2776	2.00	.6931	2.68	.9858	3.36	1.2119	4.04	1.3962	4.72	1.5518	5.40	1.6863	6.08	1.8050
1.33	.2851	2.01	.6981	2.69	.9895	3.37	1.2149	4.05	1.3987	4.73	1.5539	5.41	1.6882	6.09	1.8066
1.34	.2926	2.02	.7030	2.70	.9932	3.38	1.2178	4.06	1.4011	4.74	1.5560	5.42	1.6900	6.10	1.8082
1.35	.3001	2.03	.7080	2.71	.9969	3.39	1.2208	4.07	1.4036	4.75	1.5581	5.43	1.6919	6.11	1.8099
1.36	.3074	2.04	.7129	2.72	1.0006	3.40	1.2237	4.08	1.4060	4.76	1.5602	5.44	1.6937	6.12	1.8115
1.37	.3148	2.05	.7178	2.73	1.0043	3.41	1.2267	4.09	1.4085	4.77	1.5623	5.45	1.6956	6.13	1.8131
1.38	.3220	2.06	.7227	2.74	1.0079	3.42	1.2296	4.10	1.4109	4.78	1.5644	5.46	1.6974	6.14	1.8148
1.39	.3293	2.07	.7275	2.75	1.0116	3.43	1.2325	4.11	1.4134	4.79	1.5665	5.47	1.6992	6.15	1.8164
1.40	.3364	2.08	.7323	2.76	1.0152	3.44	1.2354	4.12	1.4158	4.80	1.5686	5.48	1.7011	6.16	1.8180
1.41	.3435	2.09	.7371	2.77	1.0188	3.45	1.2387	4.13	1.4182	4.81	1.5706	5.49	1.7029	6.17	1.8196
1.42	.3506	2.10	.7419	2.78	1.0224	3.46	1.2412	4.14	1.4206	4.82	1.5727	5.50	1.7047	6.18	1.8213
1.43	.3576	2.11	.7466	2.79	1.0260	3.47	1.2441	4.15	1.4231	4.83	1.5748	5.51	1.7065	6.19	1.8229
1.44	.3646	2.12	.7514	2.80	1.0296	3.48	1.2470	4.16	1.4255	4.84	1.5769	5.52	1.7083	6.20	1.8245
1.45	.3715	2.13	.7561	2.81	1.0331	3.49	1.2499	4.17	1.4279	4.85	1.5789	5.53	1.7101	6.21	1.8261
1.46	.3784	2.14	.7608	2.82	1.0367	3.50	1.2527	4.18	1.4303	4.86	1.5810	5.54	1.7119	6.22	1.8277
1.47	.3852	2.15	.7654	2.83	1.0402	3.51	1.2556	4.19	1.4327	4.87	1.5830	5.55	1.7137	6.23	1.8293
1.48	.3920	2.16	.7701	2.81	1.0438	3.52	1.2584	4.20	1.4350	4.88	1.5851	5.56	1.7155	6.24	1.8309
1.49	.3987	2.17	.7747	2.85	1.0473	3.53	1.2612	4.21	1.4374	4.89	1.5870	5.57	1.7173	6.25	1.8325
1.50	.4054	2.18	.7793	2.86	1.0508	3.54	1.2641	4.22	1.4398	4.90	1.5892	5.58	1.7191	6.26	1.8341
1.51	.4121	2.19	.7839	2.87	1.0543	3.55	1.2669	4.23	1.4422	4.91	1.5912	5.59	1.7209	6.27	1.8357
1.52	.4187	2.20	.7884	2.88	1.0577	9.56	1.2697	4.24	1.4445	4.92	1.5933	5.60	1.7227	6.28	1.8373
1.53	.4252	2.21	.7929	2.89	1.0612	3.57	1.2725	4.25	1.4469	4.93	1.5953	5.61	1.7245	6.29	1.8389
1.54	.4317	2.22	.7975	2.90	1.0647	3.58	1.2753	4.26	1.4492	4.94	1.5973	5.62	1.7263	6.30	1.8405
1.55	.4382	2.23	.8021	2.91	1.0681	3.59	1.2781	4.27	1.4516	4.95	1.5993	5.63	1.7281	6.31	1.8421
1.56	.4446	2.24	.8064	2.92	1.0715	3.60	1.2809	4.28	1.4539	4.96	1.6014	5.64	1.7298	6.32	1.8437
1.57	.4510	2.25	.8109	2.93	1.0750	3.61	1.2837	4.29	1.4562	4.97	1.6034	5.65	1.7316	6.33	1.8453
1.58	.4574	2.26	.8153	2.94	1.0784	3.62	1.2864	4.30	1.4586	4.98	1.6054	5.66	1.7334	6.34	1.8468
1.59	.4637	2.27	.8197	2.95	1.0818	3.63	1.2892	4.31	1.4609	4.99	1.6074	5.67	1.7351	6.35	1.8484
1.60	.4700	2.28	.8241	2.96	1.0851	3.64	1.2919	4.32	1.4632	5.00	1.6094	5.68	1 7369	6.36	1.8500
1.61	.4762	2.29	.8285	2.97	1.0885	3.65	1.2947	4.33	1.4655	5.01	1.6114	5.69	1.7387	6.37	1.8515
1.62	.4824	2.30	.8329	2.98	1.0919	3.66	1.2974	4.34	1.4678	5.02	1.6134	5.70	1.7404	6.38	1.8531
1.63	.4885	2.31	.8372	2.99	1.0952	3.67	1.3001	4.35	1.4701	5.03	1.6154	5.71	1.7122	6 39	1.8547
1.64	.4946	2.32	.8415	3.00	1.0986	3.68	1.3029	4.36	1.4724	5.04	1.6174	5.72	1.7439	6.40	1.8562
1.65	.5007	2.33	.8458	3.01	1.1019	3.69	1.3056	4.37	1.4747	5.05	1.6193	5.73	1.7457		
1.66	.5068	2.34	.8501	3.02	1.1052	3.70	1.3083	4.38	1.4778	5.06	1.6213	5.74	1.7474		
1.67	.5128	2.35	.8544	3.03	1.1085	3.71	1.3110	4.39	1.4793	5.07	1.6233	5.75	1.7491		
1.68	.5187	2.36	.8586	3.04	1.1118	3.72	1.3137	4.40	1.4816	5.08	1.6253	5.76	1.7509		

in. diameter, which has 201 square inches area, would produce an effect equal to $54.95 \times 201 = 11{,}044.9$ lbs. Therefore, if the piston moves two feet, it would exert $11{,}044.9 \times 2 = 22{,}089.8$ foot pounds of work at each stroke. Supposing though, that instead of cutting off steam at one-quarter of the stroke and then allowing it to expand, that steam had been admitted until the piston had reached the end of the cylinder. The pressure through the whole stroke would then have been 100 lbs. absolute, or 85 lbs. effective, and the amount of work done during one stroke of two feet, would be $95 \times 201 \times 2 = 38{,}190$ foot pounds. It must be noted that in the first instance, only one-quarter of a cylinderful of live steam was used, and in the second the whole cylinder was filled from the boiler, so that by using the steam expansively *one-quarter of a cylinderful did eleven nineteenths, or nearly one-half as much work as a whole cylinderful of the same pressure which was not expanded.* On the other hand, if steam of a pressure equal to the *average* pressure is worked full stroke, it would exert exactly the same force on the piston as the steam of higher tension did when working expansively, but in the latter case, when the piston reaches the end of the stroke, the *final pressure*, as it is called, would be considerably lower than in the other. The expansive force

PROPERTIES OF SATURATED STEAM.

Total pressure per sq. inch, measured from a vacuum	Pressure above the atmosphere	Sensible temperature in Fahrenheit degrees	Total heat in degrees from zero of Fahrenheit	Weight of one cubic foot of steam	Relative volume of the steam compared with the water from which it was raised	Total pressure per sq. inch, measured from a vacuum	Pressure above the atmosphere	Sensible temperature in Fahrenheit degrees	Total heat in degrees from zero of Fahrenheit	Weight of one cubic foot of steam	Relative volume of the steam compared with the water from which it was raised
Lb.	Lb.	Deg.	Deg.	Lb.		Lb	Lb.	Deg.	Deg.	Lb.	
1	..	102.1	1144.5	.0030	20582	86	71.3	316.9	1210.1	.3002	311
2	..	126.3	1151.7	.0058	10721	87	72.3	317.8	1210.4	.2024	308
3	..	141.6	1156.6	.0085	7322	88	73.3	318.6	1210.6	.3044	305
4	..	153.1	1160.1	.0112	5583	89	74.3	319.4	1210.9	.2067	301
5	..	162.3	1162.9	.0138	4527	90	75.3	320.2	1211.1	.2089	298
6	..	170.2	1165.3	.0163	3813	91	76.3	321.0	1211.3	.2111	295
7	..	176.9	1167.3	.0189	3298	92	77.3	321.7	1211.5	.2133	292
8	..	182.9	1169.2	.0214	2909	93	78.3	322.5	1211.8	.2155	289
9	..	188.3	1170.8	.0239	2604	94	79.3	323.3	1212.0	.2176	286
10	..	193.3	1172.3	.0264	2358	95	80.3	324.1	1212.3	.2198	283
11	..	197.8	1173.7	.0289	2157	96	81.3	324.8	1212.5	.2219	281
12	..	202.0	1175.0	.0314	1986	97	82.3	325.6	1212.8	.2241	278
13	..	205.9	1176.2	.0338	1842	98	83.3	326.3	1213.0	.2263	275
14	..	209.6	1177.3	.0362	1720	99	84.3	327.1	1213.2	.2285	272
14.	0.	212.0	1178.1	.0380	1642	100	85.3	327.9	1213.4	.2307	270
15	.3	213.1	1178.4	.0387	1610	101	86.3	328.5	1213.6	.2329	267
16	1.3	216.3	1179.4	.0411	1515	102	87.3	329.1	1213.8	.2351	265
17	2.3	219.6	1180.3	.0435	1431	103	88.3	329.9	1214.0	.2373	262
18	3.3	222.4	1181.2	.0459	1357	104	89.3	330.6	1214.2	.2393	260
19	4.3	225.3	1182.1	.0483	1290	105	90.3	331.3	1214.4	.2414	257
20	5.3	228.0	1182.9	.0507	1229	106	91.3	331.9	1214.6	.2435	255
21	6.3	230.6	1183.7	.0531	1174	107	92.3	332.6	12144	.2456	253
22	7.3	233.1	1184.5	.0555	1123	108	93.3	333.3	1215.0	.2477	251
23	8.3	235.5	1185.2	.0580	1075	109	94.3	334.0	1215.3	.2499	249
24	9.3	237.8	1185.9	.0601	1036	110	95.3	334.6	1215.5	.2521	247
25	10.3	240.1	1186.6	.0625	996	111	96.3	335.3	1215.7	.2543	245
26	11.3	242.3	1187.3	.0650	958	112	97.3	336.0	1215.9	.2564	243
27	12.3	244.4	1187.8	.0673	926	113	98.3	336.7	1216.1	.2586	241
28	13.3	246.4	1188.4	.0696	895	114	99.3	337.4	1216.3	.2607	239
29	14.3	248.4	1189.1	.0719	866	115	100.3	338.0	1216.5	.2628	237
30	15.3	250.4	1189.8	.0743	838	116	101.3	338.6	1216.7	.2649	235
31	16.3	252.2	1190.4	.0766	813	117	102.3	339.3	1216.9	.2674	233
32	17.3	254.1	1190.9	.0789	789	118	103.3	339.9	1217.1	.2696	231
33	18.3	255.9	1191.5	.0812	767	119	104.3	340.5	1217.3	.2738	229
34	19.3	257.6	1192.0	.0835	746	120	105.3	341.1	1217.4	.2759	227
35	20.3	259.3	1192.5	.0858	726	121	106.3	341.8	1217.6	.2780	225
36	21.3	260.9	1193.0	.0881	707	122	107.3	342.4	1217.8	.2801	224
37	22.3	262.6	1193.5	.0905	688	123	108.3	343.0	1218.0	.2822	222
38	23.3	264.2	1194.0	.0929	671	124	109.3	343.6	1218.2	.2845	221
39	24.3	265.8	1194.5	.0952	655	125	110.3	344.2	1218.4	.2867	219
40	25.3	267.3	1194.9	.0974	640	126	111.3	344.8	1218.6	.2889	217
41	26.3	268.7	1195.4	.0996	625	127	112.3	345.4	1218.8	.2911	215
42	27.3	270.2	1195.8	.1020	611	128	113.3	346.0	1218.9	.2933	214
43	28.3	271.6	1196.2	.1042	598	129	114.3	346.6	1219.1	.2955	212
44	29.3	273.0	1196.6	.1065	585	130	115.3	347.2	1219.3	.2977	211
45	30.3	274.4	1197.1	.1089	572	131	116.3	347.8	1219.5	.2999	209
46	31.3	275.8	1197.5	.1111	561	132	117.3	348.3	1219.6	.3020	208
47	32.3	277.1	1197.9	.1133	550	133	118.3	348.9	1219.8	.3040	206
48	33.3	278.4	1198.3	.1156	539	134	119.3	349.5	1220.0	.3060	205
49	34.3	279.7	1198.7	.1179	529	135	120.3	350.1	1220.2	.3080	203
50	35.3	281.0	1199.1	.1202	518	136	121.3	350.6	1220.3	.3101	202
51	36.3	282.3	1199.5	.1224	509	137	122.3	351.2	1220.5	.3121	200
52	37.3	283.5	1199.9	.1246	500	138	123.3	351.8	1220.7	.3142	199
53	38.3	284.7	1200.3	.1269	491	139	124.3	352.4	1220.9	.3162	198
54	39.3	285.9	1200.6	.1291	482	140	125.3	352.9	1221.0	.3184	197
55	40.3	287.1	1201.0	.1314	474	141	126.3	353.5	1221.2	.3206	195
56	41.3	288.2	1201.3	.1336	466	142	127.3	354.0	1221.4	.3228	194
57	42.3	289.3	1201.7	.1364	458	143	128.3	354.5	1221.6	.3250	193
58	43.3	290.4	1202.0	.1380	451	144	129.3	355.0	1221.7	.3273	192
59	44.3	291.6	1202.4	.1403	444	145	130.3	355.6	1221.9	.3294	190
60	45.3	292.7	1202.7	.1425	437	146	131.3	356.1	1222.0	.3315	189
61	46.3	293.8	1203.1	.1447	430	147	132.3	356.7	1222.2	.3336	188
62	47.3	294.8	1203.4	.1469	424	148	133.3	357.2	1222.3	.3357	187
63	48.3	295.9	1203.7	.1493	417	149	134.3	357.8	1222.5	.3377	186
64	49.3	296.9	1204.0	.1516	411	150	135.3	358.3	1222.7	.3397	184
65	50.3	298.0	1204.3	.1538	405	155	140.3	361.0	1223.5	.3500	179
66	51.3	299.0	1204.6	.1560	399	160	145.3	363.4	1224.2	.3607	174
67	52.3	300.0	1204.9	.1583	393	165	150.3	366.0	1224.9	.3714	169
68	53.3	300.9	1205.2	.1605	388	170	155.3	368.2	1225.7	.3821	164
69	54.3	301.9	1205.5	.1627	383	175	160.3	370.8	1226.4	.3928	159
70	55.3	302.9	1205.8	.1648	378	180	165.3	372.9	1227.1	.4035	155
71	56.3	303.9	1206.1	.1670	373	185	170.3	375.3	1227.8	.4142	151
72	57.3	304.8	1206.3	.1692	368	190	175.3	377.5	1228.5	.4250	148
73	58.3	305.7	1206.6	.1714	363	195	180.3	379.7	1229.2	.4357	144
74	59.3	306.6	1206.9	.1736	359	200	185.3	381.7	1229.8	.4464	141
75	60.3	307.5	1207.2	.1759	353	210	195.3	386.0	1231.1	.4668	135
76	61.3	308.4	1207.4	.1782	349	220	205.3	389.9	1232.3	.4872	129
77	62.3	309.3	1207.7	.1804	345	230	215.3	393.8	1233.5	.5072	123
78	63.3	310.2	1208.0	.1826	341	240	225.3	397.5	1234.6	.5270	119
79	64.3	311.1	1208.3	.1848	337	250	235.3	401.1	1235.7	.5471	114
80	65.3	312.0	1208.5	.1869	333	260	245.3	404.5	1236.8	.5670	110
81	66.3	312.8	1208.8	.1891	329	270	255.3	407.9	1237.8	.5871	106
82	67.3	313.6	1209.1	.1913	325	280	265.3	411.2	1238.8	.6070	102
83	68.3	314.5	1209.4	.1935	321	290	275.3	414.4	1239.8	.6268	99
84	69.3	315.3	1209.6	.1957	318	300	285.3	417.5	1240.7	.6469	96
85	70.3	316.1	1209.9	.1980	314						

of steam represents *energy*, or *capacity for doing work*, and, therefore, if we allow it to escape with a comparatively high pressure without doing work, it is a waste of energy. To illustrate this, we will take the same conditions which were used in the answer to question 87, in calculating the average pressure. In that case, the mean absolute pressure of the steam was 69.95 lbs. per square in., but the pressure at the end of the stroke, when the steam escaped, was only 33⅓ lbs. absolute. If, therefore, steam had been used of the average pressure through the whole stroke, it would have escaped with a pressure of 69.95 lbs., or more than twice that of the expanded steam, and the work done in both cases would have been the same.

QUESTION 93. *Can the economy of working steam expansively be shown in any other way?*

Answer. Yes, it can be shown if we know the "total heat" contained in a given quantity of steam used expansively and that in steam which has been used without expansion, and then compare the two quantities with the amount of work done under the two different conditions.

For the basis of the circulations the same data and dimensions will be employed that were used in the previous illustration; that is, a cylinder of 16 in. diameter, and piston with 24 in. stroke, and steam of 100 lbs. absolute pressure cut off at 8 in. of the stroke. We will suppose, further, that the steam used is generated from water of a temperature of 60 degrees, and we will then calculate the total number of units of heat in the steam used for each stroke of the piston. The area of a piston 16 in. in diameter is 201 square in.; and as the steam is admitted until the piston moves 8 in. of its stroke, therefore the quantity of steam would be 8 times 201 cubic in., or

$$201 \times 8 = 1608 \text{ cubic in.} = \frac{1608}{1728} \text{ cubic ft.}$$

From the table it will be seen that one cubic foot of steam of 100 lbs. pressure weighs 0.2307 lbs.; therefore, the weight of the fraction of a cubic foot given above would be calculated as follows:

$$\frac{.2307 \times 1608}{1728} = .2146 \text{ lbs.} = \text{weight of 1608 cubic in. of steam of 100 lbs. absolute pressure.}$$

From the table it will be seen that the total heat above zero of steam of 100 lbs. absolute pressure is 1213.4 degrees. It was explained in the answer to question 57 that one pound of water heated one degree is the standard of measurement or *unit of heat*. Now, if we have 1 lb. of water with a temperature of zero, evidently it will take 1213.4 *units of heat* to convert it into steam of 100 lbs. absolute pressure. But as the water from which our steam was generated had a temperature of 60 degrees, we must deduct that much from 1213.4: 1213.4 — 60. = 1153.4 = units of heat in one pound of steam of 100 lbs. absolute pressure generated from water of 60 degrees temperature.

If then one pound of steam has 1153.4 units of heat, the following calculation will give the units of heat in .2146 lbs.: 1153.4 × .2146 = 247.51 = units of heat in .2146 lbs., or 1,608 cubic in. of steam of 100 lbs. absolute pressure. It was shown in answer to question 94 that the average pressure of steam of 100 lbs. cut off at 8 in. of the stroke was 69.95 lbs. per square inch. So that if steam of 100 lbs. absolute pressure is used expansively it requires 247.51 units of heat to produce an average absolute pressure of 69.95 lbs. per square in. during the whole stroke. Disregarding the small fraction, we will call it 70 lbs. Now, if we admit steam of this pressure through the *whole stroke* of the piston, we will use 4,824 cubic in. It will be found by a calculation similar to the above, that to generate this quantity of steam of 70 lbs. pressure from water of a temperature of 60 degrees would require 527 units of heat, or more than twice as many as were required to do the same work with steam of 100 lbs. pressure cut off at 8 in. when using it expansively during the rest of the stroke. The actual difference in practice is not so great as this, because the loss of heat from radiation and condensation in the cylinder and other causes is greater when steam of a high pressure is expanded than when lower pressure steam is admitted through the whole stroke. But after allowance is made for all such sources of loss and waste, there is still a great gain from using steam expansively. There is is also an incidental advantage, because low-pressure steam can be exhausted more quickly from a cylinder than steam of a high pressure, and consequently there is less resistance or *back pressure*, as it is called, in the exhausted end of the cylinder to the movement of the piston.

The causes which produce the greatest economy when steam is used expansively cannot be fully explained, however, without discussing principles of science more abstruse than it is desirable to introduce here.

QUESTION 94. *To what extent can we work steam expansively with advantage and economy?*

Answer. The theoretical economy of using steam increases with the degree of expansion and the pressure. This is shown very clearly in the following table, in the first column of which the number of inches of the piston stroke is given during which steam is admitted to a cylinder 16 in. in diameter and 24-in. stroke. In the second column is given the pressure of the steam or *initial pressure*, as it is called, which must be admitted into the cylinder in order to produce a mean pressure of 70 lbs. per square inch when it is cut off at the point indicated in the first column. In the third column is given the total heat which is required to generate the steam required in each case, and in the last column the percentage of saving is given, which results from the different degrees of expansion and a mean pressure of 70 lbs. per square in. in each case.

RESULTS OF USING STEAM EXPANSIVELY.

Period of admission or point of cut-off.	Initial pressure of steam in pounds per square inch.	Total heat of steam used, in units.	Percentage of saving compared with full stroke.
Full stroke.....	70.	527.	
18 in. = Three-quarters of the stroke	72.5	408.7	22½
12 in. = One-half " "	82.7	309.5	41¼
8 in. = One-third " "	100.	247.5	53
6 in. = One-quarter " "	117.4	215.9	58
4 in. = One-sixth " "	150.5	186.5	64½
3 in. = One-eighth " "	181.8	165.8	68½
2 in. = One-twelfth " "	241.4	144.8	72½

From this table it will be seen that theoretically 22½ per cent. of heat is saved by cutting off at ¼ of the stroke and using steam of 72.5 lbs. pressure instead of steam of 70 lbs., worked full stroke. Cutting off at half-stroke and using steam of 82.7 lbs., 41¼ per cent. of heat is saved, and cutting off at quarter-stroke with steam of 117.4 lbs., saves 58 per cent. of heat; and at one-twelfth of the stroke, or expanding steam of 241.4 lbs. pressure to twelve times its volume, saves 72½ per cent of heat.

As stated before, the above is the *theoretical* advantage of using steam expansively. There are, however, practical difficulties in the way of using some of these high degrees of expansion. It has already been explained that, if steam is cut off early in the stroke and the degree of expansion increased, the pressure and consequently the temperature of the steam must also be increased. The danger of explosion is greater with the higher pressures, and stronger and more expensive boilers and machinery are therefore needed. With steam of very high temperature the metal of the cylinders, pistons and valves becomes so much heated that they soften, and then the friction of the one on the other causes them to cut or scratch each other. The high temperature at the same time destroys the oil or other lubricant used in contact with the steam. It is also impossible to admit and cut off steam very early in the stroke with the ordinary mechanical appliances used for moving slide-valves of locomotives. This latter difficulty and the effect of expansion in equalizing the pressure in the crank and lessening the strains and shocks on the mechanism of the engine will be more fully explained hereafter.

QUESTION 95. *How may the amount of expansion that can be made practically useful be illustrated and explained?*

Answer. It was shown in answer to question 90, that the main effective pressure represented by the indicator card shown in fig. 47, if steam of 100 lbs. pressure is admitted into the cylinder during one-third of the stroke, and it is allowed to expand during the rest of the stroke, will be 54.95 lbs. per square inch. As the stroke of the piston is 2 feet, the number of foot-pounds of work which would be exerted for each square inch of area of the piston during each stroke would be 54.95 × 2=109.9. Let *i j n o p*, Fig. 48, represent this card, and we will suppose that the cylinder is lengthened so that the piston will have 4 ft. stroke instead of 2 ft., and that the steam is expanded six times instead of three times. The indicator diagram which the steam would then make would be represented by *i j n k p*. By calculating the mean effective pressure for the whole stroke of 4 ft., in the manner already described, it will be found to be 31.53 lbs. As this pressure is exerted through 4 ft. of stroke, the work done per square inch of piston will be 31.53 × 4=126.12 foot-pounds or a gain of nearly 15 per cent. It should be observed that to secure this economy the cylinder and a number of other parts of the engine must be doubled in size.

QUESTION 96. *What will be the result, if, instead of increasing the size of the cylinder and rate of expansion, we double the "initial pressure"* of the steam which is introduced into the cylinder, and then cut it off at one-sixth of the stroke instead of one-third?*

Answer. The effect of this can be shown if we draw a diagram, *l m n o p*, in which the initial pressure represented by the height *l p* is 200 lbs. absolute, instead of 100, and the steam is supposed to be cut off at *m*, or at 4 in. of the stroke, instead of 8, and the piston to have a stroke, *p o*, of 2 ft. If the average pressure is then calculated as before, it will be found to be

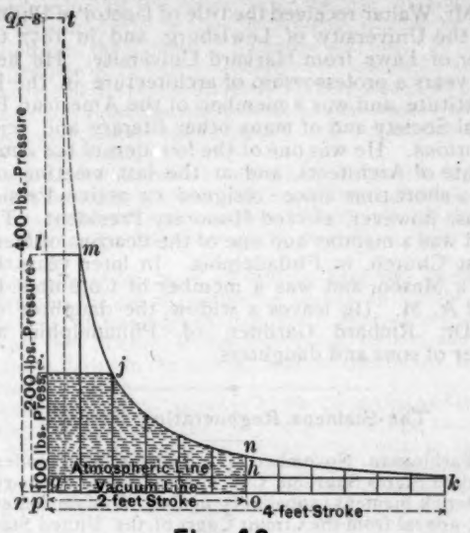


Fig. 48

78.06 lbs. per square inch, so that the work done for each square inch of area of the piston during each stroke will be 156.12 foot lbs. instead of 109.9, or a gain of over 42 per cent., with steam of 100 lbs. pressure expanded three times. By referring to the table of the properties of steam it will be seen that with 100 lbs. pressure the total heat is 1213.4, and with 200 it is 1229.8 a difference of 16.4 degrees or units or only a little over 1⅓ per cent. more. That is, theoretically, by adding 1⅓ per cent. more heat to the steam and expanding it twice as much, there is a gain of 42 per cent. in the amount of work done. To do this, though, the boiler and engine must be made twice as strong to resist these high pressures.

We may assume still further that the stroke is lengthened, and the steam of 200 lbs. pressure is expanded twelve times, as indicated by the diagram *l m k p*, and also that the pressure is increased to 400 lbs. and the steam expanded to twelve times, as shown by the diagram *s t m n o p*, or twenty-four times as represented by *s t k p*. In the following table the calculated results from these high pressures and rates of expansion are given:

1	2	3	4	5	6	7	8	9
	Initial Pressure in lbs. per square inch.	Rate of expansion.	Average cylinder pressure.	Foot lbs. of work done per stroke for each inch in area of cylinder.	Percentage of gain.	Boiler strength of	CYLINDER.	
							Size of	Strength of
a	100	3	54.95	109.09		1	1	1
b	100	6	31.53	126.12	15	1	2	1
c	200	6	78.06	156.12	42	2	1	2
d	200	12	43.08	172.32	57	2	2	2
e	400	12	101.00	202.00	83	4	4	2
f	400	24	54.6	218.4	100	4	4	4

Column 5 shows the gain in foot-pounds of work done per square inch of piston, and from the increased steam pressure and higher rates of expansion. Column 6 gives the percentage of gain in the work done when compared with the results with steam of an initial pressure of 100 lbs expanded three times. Columns 7, 8 and 9 give the relative strength of the results with steam of an initial pressure of 100 lbs. expanded boiler and size and strength of cylinder required in each case. From the line *b* it will be seen that, by doubling the rate of expansion, there is a gain of 15 per cent., but the cylinder must then be twice as large as before. This means an increase in size and strength of other parts. To gain 42 per cent., by doubling the pressure and rate of expansion as shown in the line marked *c*, the boiler and cylinder must both be doubled in strength. A gain of 57 per cent., by doubling the pressure and quadrupling the rate of expansion, requires the strength of boiler and size and strength of engine all to be doubled, and the gain of 100 per cent. in the last line compels the strength of boiler and strength and size of cylinder all to be quadrupled. From this table it is obvious that we soon reach a point at which increasing the steam pressure and rate of expansion involves so much expense for the larger size and strength of boiler and engine, that the gain in the work done will not pay for the increased cost.

*The pressure of the steam when it is first admitted to the cylinder and before it is cut off is called the *initial pressure*.

QUESTION 97. *Can as much be gained practically from increased rates of expansion, as the preceeding examples have indicated was possible?*

Answer. No. In every engine there is always a very considerable loss of heat from radiation, conduction, and from the conversion of heat into work, and probably from causes not yet perfectly understood.

QUESTION 98. *What can be done to lessen this loss of heat?*

Answer. The most important thing to do is to cover the boiler, cylinders and steam-pipes with the most perfect non-conductor of heat that can be used.

QUESTION 99. *What other reasons are there why very high degrees of expansion are not practicable on locomotives?*

Answer. There is the difficulty that the valve-gear which is now generally used will not admit steam freely to the cylinders and cut it off short: and next, high rates of expansion require either large cylinders or high initial pressure. In either case, it means that the propelling force, exerted to turn the wheels will be excessive during some portions of each revolution of the wheels, and will thus cause them to slip. This will be explained in a future chapter.

QUESTION 100. *What is meant by wire-drawn steam?*

Answer. It is steam which has had its pressure reduced by passing through contracted openings or passages.

QUESTION 101. *What is the economical effect of reducing the pressure, or of wire-drawing it, by partly closing the valve by which it admitted to the cylinders.*

Answer. By reducing the pressure of steam in this or any other way, it is necessary in doing the same amount of work to admit steam to the cylinder for a longer period, and, therefore, to reduce the degree of expansion. To illustrate the effect of this, we will estimate the total heat required to exert a pressure of 70 lbs. on the piston described above. It will be assumed that the steam pressure in the boiler is 100 lbs. absolute, and that this is wire-drawn down to 70 lbs. and admitted to the cylinder through the whole stroke. As was shown in the preceding answer, 4.824 cubic in. of steam are required to fill the cylinder. Now, 3,376.8 cubic in. of steam of 100 lbs. pressure, if expanded to 70 lbs. pressure, will make 4.824 cubic in. The total heat required to generate 3,376.8 cubic in. of steam of 100 lbs. absolute pressure from water of 60 degrees is 519.9 units, so that to do the same work by using steam of *high-pressure cut-off at one-third of the stroke*, using steam of *low-boiler pressure full stroke*, and using *wire-drawn steam full stroke*, would, in the example we have selected, require 247.5, 527 and 519.9 units of heat respectively.

(TO BE CONTINUED.)

OBITUARY.

JOSEPH CURTIS PLATT, who died in Scranton, Pa., November 15, was one of the founders of that city. He was born at Saybrook, Conn., in 1816, and went to Pennsylvania in 1846. In 1851, he joined with Joseph H. and E. C. Scranton in business, and in 1853 assisted in organizing the Lackawanna Iron & Coal Company, of which he was Vice-President for many years. He retired from business in 1875, but was still a director in his old company, in the Dickson Manufacturing Company and several other corporations, and took an active interest in their management.

PROFESSOR GUSTAV KIRCHHOFF, who died recently at Berlin, Germany, aged 63 years, held a very high place in the scientific world. His remarkable works in the department of physical science, especially in relation to light and elecicity, are standards both for students and

for other investigators. His name will be perpetuated by his discoveries in relation to the dark lines of the spectrum, or the lines of Frauenhofer, as they are called. The laws of the propagation of the electric current, extensions of the laws of Ohm, are universally known in Europe as the laws of Kirchhoff. Herr Kirchhoff was Professor of Physics at the University of Berlin; a member of the Imperial Academy of Science, corresponding member of the French Academy of Science and of many other scientific bodies.

DAVID MORGAN, President and General Manager of the Republic Iron Company, whose mine is situated near Marquette, Mich., and one of the richest men in the iron world, died October 30, at Asheville, N. C., where he was taken by his physicians in the hope of saving his life. Mr. Morgan was born in Swansea, Wales, in 1819, and went to Pennsylvania with his parents when 17 years old. He began as a miner in the coal mines, then became an operator, and finally an extensive employer in the coal and iron business in Ironton, O. He moved to Marquette, Mich., in 1875, and had since given his entire time to his great mine, in which he became a stockholder when the stock was almost valueless, seeing it go up to nearly $200 a share on a par value of $25. He leaves an only child, Mrs. Charles Hebard, of Pequaming, Mich. The remains were buried at Wilkes-Barre, Pa., Mr. Morgan's old home.

MAJOR ALFRED MORDECAI, who died in Philadelphia, October 23, aged 83 years, graduated from West Point in 1823, at the head of his class. He served in the Engineer Corps and the Ordnance Corps, rising to the rank of Major; he resigned in 1861. From 1863 to 1866 he was Assistant Engineer of the proposed Mexico & Pacific road, and in 1867 he was made Secretary and Treasurer of the Pennsylvania Canal Company, holding that position till his death. He was author of "Reports of Experiments on Gunpowder," 1845 and 1849; of "Artillery for the United States Land Service, as Devised and Arranged by the Ordnance Board, with Plates," 1849, and of the "Ordnance Manual, for the Use of the Officers of the United States Army" (second edition), 1850. Major Mordecai was a man of the highest order of talent and an officer of marked professional ability and experience. His "Reports of Experiments on Gunpowder" were a great advance on the knowledge possessed 40 years ago; and even at this day, notwithstanding modern improvements, those reports are classics in every military library. His "Artillery for the Land Service" and the "Ordnance Manual" were text books in the Army long before the advent of steel guns and steel carriages, brown powder and explosive gelatine. Modern methods and advances, new materials and explosives and newly developed forces may seem to dwarf the appliances and knowledge of the first half of our century, but at that time Major Mordecai's attainments were second to none in the military world in the field of scientific research and accomplishment and in practical application of mechanical deductions to war uses.

DR. THOMAS USTICK WALTER, who died in Philadelphia, October 30, was the oldest and most distinguished architect in that city, and one of the best known in the United States. He was born in Philadelphia in 1804, and studied architecture under Mr. William Strickland and afterward mathematics under David McClure, then distinguished as a teacher of that science. He applied himself assiduously to study for many years before he commenced the practice of his profession. He designed in 1831 and superintended the erection of the Philadelphia county prison. His designs for the Girard College were adopted by City Councils in 1833, and that magnificent building, perhaps the finest specimen of classic architecture on the American continent, was constructed throughout from Mr. Walter's designs and under his immediate supervision. This work occupied him for 14 years. In 1851, Mr. Walter's plans for the extension for the Capitol at Washington were adopted, and he was appointed Architect of the work by President Fillmore, a position which he held for 14 years. In addition to the work of the Capitol extension he planned and executed the new dome of the Capitol, the east and west wings of the Patent Office and the extension of the General Post Office. He also designed the new Treasury building and the Government Hospital for the Insane. During the latter years of his life Mr. Walter acted as assistant to Architect McArthur at the new public buildings, Philadelphia. In 1853, Mr. Walter received the title of Doctor of Philosophy from the University of Lewisburg, and in 1857 that of Doctor of Laws from Harvard University. He held for many years a professorship of architecture in the Franklin Institute, and was a member of the American Philosophical Society and of many other literary and scientific institutions. He was one of the founders of the American Institute of Architects, and at the last meeting of that body, a short time since, resigned its active Presidency. He was, however, elected Honorary President. The deceased was a member and one of the deacons of Memorial Baptist Church, in Philadelphia. In later years he became a Mason, and was a member of Columbia Lodge, F. and A. M. He leaves a widow, the daughter of the late Dr. Richard Gardner, of Philadelphia, and a number of sons and daughters.

The Siemens Regenerating Furnace.

IN Washington, November 14, a decision was rendered by the United States Supreme Court in the case of Charles W. & Frederick Siemens, appellants, against William Sel'ers and others; appeal from the Circuit Court of the United States for the Eastern District of Pennsylvania. This is a suit for alleged infringement of a patent granted to the Siemens Brothers, of England, upon their well-known regenerating furnace. The defendants do not deny that the Siemens Brothers were the authors of the ingenious invention covered by the patent, nor do they deny they use it. Their contention is that the Siemens Brothers took out an English patent for the same invention on July 19, 1861, and that by force of the acts of 1839 and 1861 the American patent expired at the end of 17 years from the sealing of the English patent, namely, on July 19, 1878. They deny that they used the said invention before the last mentioned date, and no evidence is given that they did so. The questions to be decided, therefore, are whether the English patent was for the same invention as the American patent, and, if so, whether the latter was limited to expire at the end of 17 years from the sealing of the former. The Court holds that both of these questions must be answered in the affirmative, and it therefore sustains the decree of the Circuit Court in favor of the American users of the Siemens invention. The opinion was drawn up by Justice Bradley.

Manufacturing Notes.

BLAINE BROTHERS have completed shops at Green Cove Springs, Fla., with a capacity of two box cars a day.

THE Harrisburg Car Manufacturing Company has received an order for 1,150 new freight cars for the Philadelphia & Reading Railroad.

THE Atlanta Car Company has been organized in Atlanta, Ga., with $100,000 capital, and will build car shops at once. C. F. Lucas, late of the car shops at Anniston, Ala., is Superintendent.

THE Massillon Bridge Company at Massillon, O., has taken a contract to build an iron bridge, 250 ft. long, over the Embarrass River near Newton, Ill., for the Indiana & Illinois Southern Railroad.

THE St. Charles Car Company in St. Charles, Mo., includes among recent orders 7 passenger cars for the St. Louis, Alton & Terre Haute; 250 box cars for the Mexican Central, and 600 coal cars for the Atchison, Topeka & Santa Fe.

THE Decatur Car Wheel & Spring Company has been organized at Decatur, Ala., and has begun to build a car-wheel foundry. A shop for making springs is to be added. E. Stanley Mitchell, of Milwaukee, Wis., is President; R. M. McCullough, Secretary and Treasurer.

Proceedings of Societies.

International Railroad Congress.

THE second meeting of the International Railroad Congress, which was held at Milan, Italy, in October, brought together a large number of railroad men from all parts of Europe. The chief technical subjects discussed were the use of metal ties; the construction of passenger cars; the use of continuous brakes; the use of iron or steel for bridges; journal-boxes and lubrication, and the lighting of trains and stations. In relation to the operation of railroads reports were submitted and discussions held of the best methods of working secondary (branch or light feeder) railroads; the control of passenger traffic; co-operative associations for employés, and the employment of women on railroads.

The questions which called out the most discussion, apparently, were those relating to the building and management of light or secondary railroads as branches and feeders of the main lines, and on these questions there was much difference of opinion.

One question that is now of interest here was discussed at some length—the use of continuous brakes on freight trains. On this point it was agreed that their general introduction would be very difficult, if not impossible, on account of the great dissimilarity in the rolling stock in use in the different countries of Europe.

French is the official language of the Congress, and the English delegates took little part in the proceedings, as most of them were unable to express themselves freely in that language. One or two railroad men from the United States were present as spectators, but the only official delegates from America in the Congress represented Mexico and the Argentine Republic.

The next meeting of the Congress will be held in Paris in 1889.

American Society of Civil Engineers.

AT the regular meeting in New York, November 2, the final report of the Committee on proposed changes in grades of membership was presented, substantially as given in our last issue.

Several amendments in relation to ballots for members were presented.

The following elections were announced:

Members.—George Earl Church, London, Eng.; Henry Stevens Haines, Savannah, Ga.; David Carlisle Humphreys, St. Louis, Mo.; William Datus Kelley, Jr., Tarrytown, N. Y.; Rowland Robinson Minturn, Milwaukee, Wis.; James Moylan, New York; Cornelius Palmer, Escanaba, Mich.; William Barclay Parsons, New York; Edward Fesser Playle, New York; Albert Fowler Robinson, St. Paul, Minn.; Orlando Belina Wheeler, St. Louis, Mo.

Associate.—Arthur James Moxham, Johnstown, Pa.

Juniors.—Archie McLean Hawks, St. Louis, Mo.; Downing Vaux, New York.

A long and interesting paper was presented by L. L. Buck on Replacing the Stone Towers of the Niagara Railroad Suspension Bridge with Iron Towers.

A regular meeting was held November 16, at which papers were read by Mr. C. L. Strobel on Experiments on Z-iron Columns, and also one by Mr. A. P. Boller on Test of a Wrought Iron Double-track Floor Beam. The latter was discussed at some length.

Mr. S. S. Wheeler exhibited a Chart of Wire Gauges, showing the many gauges in use and their differences.

Engineers' Club of St. Louis.

A MEETING was held in St. Louis, November 2, President Potter in the Chair. The Executive Committee submitted the following programme for the meetings of the season:

"November 2.—Chas. E. Jones, Steam Heating at Washington University.

"November 16.—Prof. J. B. Johnson, Testing the Strength of Engineering Materials.

"December 7.—Annual meeting—P. M. Bruner, The Action of Frost on Concrete Work.

"December 21.—Isaac A. Smith, Rapid Railway Embankment Construction.

"January 4.—Chas. H. Ledlie, Construction of Dam and Reservoir at Athens, Ga.; Chas. W. Bryan, Railway-Bridge Designing.

"January 18.—Carl Gayler, Floors of Street Bridges; N. W. Eayrs, The Improvement of Nantucket Harbor, Mass.

"February 1.—Prof. F. E. Nipher, Graphical Solution of the Action of the Series Dynamo; B. F. Crow, Constructive Accounts.

"February 15.—Robert Moore, Sizes of Railroad Culverts; O. L. Petitdidier, Practical Notes on Masonry and Stone Laying.

"March 7.—Prof. H. B. Gale, The Transmission of Power by Belting; Samuel F. Burnet, Cement and Mortar.

"March 21.—Prof. W. B. Potter, St. Louis Water Supply.

"April 4.—S. Bent Russell, Thickness of Water Pipes; H. A. Wheeler [subject not yet announced].

"April 18.—Prof. C. M. Woodward, Gas Producers; Lewis Stockett, A Well-Ventilated Mine.

"May 2.—Col. E. D. Meier, Standards of Boiler Efficiency; Chas. F. White, The Failure of a Firmenich Boiler.

"May 16.—R. E. McMath, the Waterway Between the Lakes and the Mississippi River.

"June 6.—M. L. Holman, The Temporary Low-Service Pumping Plant at St. Louis.

"Partial promises have been made of other papers on topics of interest. These will be presented as opportunity occurs and due notice given."

Professor Johnson read a communication from the Board of Managers of the Association of Engineering Societies on the subject of a closer union between the Societies now in the Association and others. On motion the consideration of this paper was made a special order for the next meeting, November 16.

Mr. Chas. E. Jones then read a paper on Steam Heating at Washington University, and Experience with Underground Pipes. The history of the system in use was given with details of its construction and the work done. It was shown that the boilers were regularly doing double the duty which was originally expected of them. The evaporative efficiency did not seem to be reduced when the boilers were forced in this manner. Great efforts had been made to reduce the smoke, and many devices had been tested. All had failed on account of the excessive duty required of the boilers. The underground pipes had failed after years of service from external corrosion due to the accidental admission of moisture to the conduits. New pipes had been laid recently, and the construction of the new conduit was shown.

Professors Woodward, Potter, Gale and Messrs. Bryan and Sharman took part in the discussion. Mr. Jones added that a new stack had just been erected, which had increased the draft sufficiently to permit the introduction of a small amount of air above the grates. This had resulted in an appreciable reduction of the smoke.

A REGULAR meeting was held November 16. The regular order of the day was taken up, being a communication from the Board of Managers of the Association of Engineering Societies. The discussion was participated in by Col. H. C. Moore, Professors Johnson and Nipher, Messrs. Robert Moore, Russell, Seddon, Ockerson, Bryan and R. E. McMath; also, on invitation, by Mr. A. W. Wright, of Chicago. On motion the following was adopted:

"*Resolved*, That in the opinion of the Engineers' Club of St. Louis an attempt at an organic union is not desirable. We therefore decline to favor the recommendation of the Board of Managers."

The following Committee on Nominations of officers for the coming year was then elected: J. A. Seddon, Chairman; R. E. McMath, S. B. Russell, E. A. Engler, J. A. Ockerson.

Prof. Johnson then read a paper on Testing the Strength of Engineering Materials. His remarks were illustrated by sketches on the board; he also showed numerous test pieces of iron, steel, brick, stone and wood; also a small testing machine as used. The paper was discussed by Messrs. Russell, Moore, Engler, Seddon, Potter and Nipher, the latter exhibiting a cast-iron cup which had been attached to the bottom of a piece of wrought-iron pipe, filled with water, and broken by firing a rifle ball from above into the water.

Western Society of Engineers.

A REGULAR meeting was held in Chicago, November 1. John F. Barney and Jacob Rodatz were elected members. The resignation of Mr. L. P. Morehouse as Secretary was discussed and a committee of three was appointed to prepare some fitting recognition of his services and to appoint a successor.

A display of work by the engineering students of the University of Michigan was made.

Mr. Scherzer presented a written discussion of the paper read by Mr. Lundie at the preceding meeting, on the Economical Height of Bridge Trusses. The paper was discussed orally by Messrs. Artingstall and Strobel.

Western Railway Club.

THE regular monthly meeting was held in Chicago, November 16. The subject of Extension Smoke-boxes and Fire-box arches was opened by Mr. John Hickey, who spoke at some length of the advantages to be gained by their use. The discussion was continued by Messrs. Swanson, Mackenzie, Verbryck, Forsyth, Rhodes and others.

Mr. W. L. Brown read a paper on the Relative Strength of Sap and Heart in Norway Pine, especially Relating to Sills of Freight Cars. The paper contained numerous drawings, diagrams, statistics, etc. It was briefly discussed by Messrs. Hickey, Brown, Rhodes, Verbryck and Shroyer.

The subject of Standard Axle for 60,000 pound Cars was briefly discussed by Messrs. Barr, Shroyer, Swanson and Forsyth.

It was resolved that a committee of three be appointed to recommend the proper sizes of car axle for a 50,000 and a 60,000-pound car, and at the same time to express its recommendation whether they should adopt a collarless axle or not; also to determine whether they can maintain the original length between centers of journals according to the old M. C. B. standard.

The Chairman appointed as members of this Committee Messrs. Verbryck, Shroyer and Hickey.

New York Railroad Club.

THE regular monthly meeting was held in New York, November 17. The discussion of the question of Heating and Lighting Passenger Cars was continued.

New England Railroad Club.

THE regular monthly meeting was held at the rooms in the Boston & Albany Station, Boston, November 9.

An invitation to attend the tests of the Westinghouse freight brake was received.

It was resolved to appoint a committee to co-operate with the one already appointed by the Western Railway Club in selecting some uniform coupling for use between cars equipped for heating by steam from the locomotive. The President appointed F. D. Adams, J. W. Marden and Albert Griggs as this committee.

The discussion of the subject for the evening—Axles, Journal Bearings and Lubrication—was then opened by Mr. Marden, who urged the use of a larger journal and better material for axles.

President Lauder described the Johann journal-box and advocated its use. He also advocated larger journals.

The discussion was continued by Messrs. Adams, Howard, Shinn and others.

The subject for discussion at the December meeting is Continuous Brakes for Freight Trains.

Boston Society of Civil Engineers.

A REGULAR meeting was held at the rooms in the Boston & Albany Railroad Station, Boston, November 16, 59 members and 25 visitors present.

The Committee on Weights and Measures reported on the communication from the Western Association of Architects asking a concert of action in petitioning Congress to adopt the metric system in all departments of the government for all public business, and recommended that a canvass of the Society be made to ascertain the opinion of the members upon the matter. The recommendation was adopted. The usual appropriations were made for renewing subscription to the Society's periodicals and for binding.

Mr. A. V. Abbott, Chief Engineer of the National Superheated Water Company of New York, gave a very full description of the plant now being built by the Boston Heating Company. A full-sized section of the main pipes used, together with the expansion joint, house connections and other parts of the system, were exhibited and fully explained.

Connecticut Association of Engineers and Surveyors.

THE fall meeting was held in Hartford, Conn., November 9. The members inspected the new work at the Asylum Street crossing and other engineering work in progress in and near the city.

Mr. C. E. Chandler read a paper on the Rental Value of Hydrant Service, which was discussed by the members present.

The annual meeting of the Association will be held January 10 next.

Engineers' Club of Philadelphia.

A REGULAR meeting was held at the Club's House in Philadelphia, October 15, Past President Frederic Graff in the chair; 20 members and 1 visitor present.

Mr. A. Marichal presented a description of the Gileppe Dam, Belgium, illustrated by photograph and drawings, and followed by a discussion having for its object to prove that a saving of 50 per cent. of masonry could have been effected, together with an increase of stability, by adopting a profile taken from his Diagram for the Construction of Reservoir Walls, presented to the Club on May 21, 1887.

Mr. A. Saunders Morris presented notes upon Connections for Secondary Batteries.

Arrangements for connecting the elements of storage batteries have given some trouble, principally on account of oxidation. The best form of connection is one in which the joint is removed as far as possible from the acid, and which can be readily detached for the purpose of removing the element.

Several forms of binding posts or connections were exhibited, made of tough lead alloy. Both male and female threads are cast, so that the castings are turned out of the molds, completely finished, at the rate of one per minute. The mold for casting the screws was also exhibited.

The Secretary presented, for Mr. W. H. Nauman, a description of Tests for Riveted Joints made at Watertown Arsenal, Massachussetts, for the Bureau of Steam Engineering, September, 1886, accompanied by very complete drawings and tables.

Mr. Henry Roeske, of Philadelphia, introduced by the Secretary, presented an illustrated description of a system of Water Filtration, devised by him. He preceded this description by a historical sketch of the filtration of water and the various principal devices which have been used for the purpose of accomplishing it. Mr. Roeske's filter consists of a series of compartments so arranged that a large excess of water can be used for agitating and cleansing the filtering material in each compartment separately, while the rest of the compartments are furnishing a continuous supply of filtered water. The material in each compartment is designed to be cleansed at intervals of hours or days, as may be desired, by the action of automatic valves, which are operated by a lever, formed of pipe which fills with water at the designed intervals, and by its thus increased weight operates the valve. Sand and coke are the materials used. They are placed in separate compartments, the design being to protect the coke from the coarser impurities, so as to lengthen the time of its use. It is intended that the coke be used, also, as fuel after removal from the filter.

A REGULAR meeting was held November 5, President T. M. Cleemann in the Chair; 17 members present.

The Tellers reported the following elected active members: Henry I. Snell, Henry B. Seaman, Frank Cooper, Arthur H. Wood, Erwin Graves, I. H. Wainwright and Fred J. Amweg.

The Secretary called attention to the fact that December 17 of this year would be the tenth anniversary of the organization of the Club, and recommended that it be observed by the holding of a reception in the Club House on that evening. After some discussion the following resolution, was unanimously adopted:

"*Resolved*, That a Committee, with power to act, be appointed to take charge of a Decennial Anniversary Reception, to be held in Club House on December 17, 1887, at 8 o'clock, P. M.; said Committee to consist of as many members as Chair may decide, who shall issue cards of invitation, given on request of members, the latter to be entitled to invite not exceeding three members of the engineering or architectural professions, all members being requested to subscribe $2 by notice sent by the Secretary, and that such other invitations may be issued as the Committee shall deem proper and desirable."

The President appointed as the Committee: Percival

Roberts, Jr., Chairman; E. V. d'Invilliers, L. M. Haupt, C. G. Darrach and Frederic Graff.

Mr. C. G. Darrach presented a paper on Boiler Specifications, which was discussed at length by Messrs. John T. Boyd, Chas. T. Thompson, A. Marichal, J. E. Codman and others. At a late hour Mr. Codman moved that the discussion be continued, and that such copies of the specifications as the author could supply be sent to such members as would probably take part in the discussion, which was adopted.

Engineers' Club of Kansas City.

A REGULAR meeting was held at the rooms in Kansas City, Mo., November 7. Mr. Wynkoop Kiersted was elected a member.

The Secretary read a letter from the Executive Board of the Council of Engineering Societies, inviting co-operation. It was voted that the President appoint a Committee of three to act in conjunction with the other Committees of the Council. The President appointed Messrs. Chanute, Breithaupt and Wise.

Mr. Wynkoop Kiersted read a paper on Water Supply and its Development for Small Cities in the West, which was then discussed.

Engineers' Club of Minneapolis.

AT the last meeting of the Club, Horace E. Horton, of Rochester, Minn., was elected a member. Mr. James Rigby read a paper on Gas and Light. He showed how vast had been the progress in artificial lighting, and yet how little understood the subject is at present. He had with him some interesting drawings.

The Club will hold meetings semi-monthly during the winter.

American Institute of Architects.

THE 21st annual convention was held in Chicago, October 19, and continued for three days. The business of the convention was disposed of, and papers were read by Messrs. D. Adler, M. G. Bell, W. W. Boyington, D. H. Burnham, J. C. Cady, C. H. Harn, John Moser, J. L. Smithmeyer, J. M. Wilson and others.

The following officers were elected for the ensuing year: President, R. M. Hunt, New York; Secretary, William A. Potter, New York; Treasurer, O. P. Hatfield, New York. Board of Trustees, N. Le Brun, New York; L. T. Scofield, Cleveland; H. M. Congdon, New York; John W. Root, Chicago. Committee on Education, Professor N. Clifford Ricker, Urbana, Ill.; Alfred Stone, Providence; Professor W. R. Ware, New York; J. W. McLaughlin, Cincinnati; Henry Van Brunt, Boston. Committee on Publication, Charles Crapsey, Cincinnati; T. M. Clark, Boston; S. S. Beman, Chicago; George C. Mason, Jr., Newport. Secretary for Foreign Correspondence, Arthur Rotch, Boston.

American Society of Mechanical Engineers.

THE annual meeting of this Society was to be held in Philadelphia, November 28, continuing until December 2. The programme includes opening session and annual address by the President, November 28; business meeting November 29; sessions for reading of papers and discussion, November 29 and 30; excursion to Bethlehem, December 1. Invitations have been received to visit industrial establishments at Bethlehem; also a large number in Philadelphia. A reception at the Academy of Fine Arts was to be held on the evening of November 30.

The following papers are to be presented and discussed at this meeting.

Lewis F. Lyne: The Use of Kerosene Oil in Steam Boilers.

Henry I. Snell: Method of Ventilating and Heating Office and Warehouse.

John E. Sweet: A New Principle in Piston Packing.

R. H. Thurston: Internal Friction of Non-Condensing Engines.

John J. Grant: The Milling Machine as a Substitute for the Planer.

Henry I. Snell: Centrifugal Fan Blowers and the Power to drive them.

John Coffin: Steel Car Axles.

Oberlin Smith: Power Press Problems.

Frank Van Vleck: Standard Section Lining.

Percy A. Sanguinetti: Divergencies in Flange Diameters in Pumps, etc.

Wm. O. Webber: Centrifugal Pump Efficiencies.

Gaetano Lanza: Friction of Toothed Gearing.

Jerome Sondericker: How to Test Strength of Cements.

H. deB. Parsons: Influence of Sugar upon Cements.

James M. Dodge: New Method of Stocking and Reloading Coal.

E. C. Felton: Results obtained from Steel Tested shortly after Rolling.

O. C. Woolson: Road-bed for Railroad Bridge Structures.

The following subjects and queries for topical discussions were also to be presented at this meeting:

50. What is the best form of pump to use with driven wells, where lift is 10 to 20 ft., and air is likely to get into the suction. Should the pump be single or duplex, and with piston or plunger?

51. Have you used driven wells successfully; of what sizes and depths, and singly or in groups?

52. Are roller-bushings expedient in journals at low velocities and under high pressures?

53. What is the best material for lining brake-straps on elevators, cranes, etc.?

54. What is the best way to secure tight fit of set-screws tapped into heavy parts of a machine?

55. How much should be removed from the edges of punched or sheared steel plate to cut away the injured metal?

56. Have you used power molding-machines successfully in the foundry.

57. What makes the best molds for complicated steel castings to secure solidity and freedom from shrinkage cracks?

58. What is the effect of adding small per cents. of wrought-iron or steel scrap in the foundry cupola or ladle?

59. What kinds of pig-iron give the best results in light castings, where easy tool-treatment is the essential rather than strength?

Brotherhood of Locomotive Engineers.

AT the annual convention in Chicago, October 26, the opening address of Grand Chief Engineer P. M. Arthur presented the following facts concerning the Brotherhood:

"A mighty army of men, representing 365 divisions, has gathered about a nucleus of 12 men, who, 24 years ago, assembled in the City of Detroit and started an organization destined to be more than they knew or dreamed.

"To-day we number 25,000 men, and, while our numbers are great, we would not have you consider only the quantity, but the quality as well. To be a Brotherhood man, four things are required, namely, sobriety, truth, justice and morality. This is our motto, and upon this precept have we based our practice. At last year's convention we deemed it best to slightly change our plan of insurance, so as to bring it within the reach of all. We now claim to have at once the cheapest and the best, the most satisfactory, insurance in existence. We have paid out during the fiscal year just closed, to widows and orphans, $259,500, making a total of $2,244,669 that we have paid since the organization was established in December, 1867.

"At the close of the last fiscal year we had 4,444 members. Died during the year, 77; disabled, 11; forfeited, 183; and had on September 1 last 6,287, showing a net gain of 1,843. Our *Journal's* circulation has now reached 22,000, from which we derive a revenue of $8,922 per year. During the year our Chief Executive has traveled over 50,000 miles of territory, adjusting grievances and attending union meetings.

"Taking all things into consideration, our relations—both to ourselves and with various railroads employing Brotherhood men—are amicable. When we consider the dissatisfaction which is everywhere manifested about us (almost can we feel it in the air which surrounds us) our few troubles pale into insignificance."

Master Mechanics' Association.

THE following committee circulars have been issued by the Secretary, Angus Sinclair, from his office, No. 175 Dearborn Street, Chicago:

TRACTION-INCREASERS IN CONNECTION WITH OVER-CYLINDERED ENGINES.

Can the defect of an over-cylindered engine be best remedied—

(*a*) By the application of a traction-increaser; or

(*b*) Would you in preference recommend that the cylinders

be lined with a steel bush (a practice common in marine service); or

(*c*) That additional dead weight be judiciously distributed all over the driving wheels; or

(*d*) That a lower boiler pressure be used with an altered ratio of steam expansion?

2. If you approve of the use of traction-increasers on the standard American engine, would you also recommend their application to Mogul, Consolidation and Decapod engines? If not, why would you restrict their use to four-wheel-coupled engines?

3. Having equipped an engine with traction-increaser, would you dispense with sand and sand-box?

4. (*a*) In your opinion does a traction-increaser practically lengthen the engine wheel-base, thereby increasing the locomotive resistance on curves?

(*b*) Can you quote an experiment showing the difference in haulage capacity of an engine so equipped—first on tangent and then on curve?

(*c*) If you have an engine equipped, will you try this experiment, and communicate the results?

5. If traction-increasers are of acknowledged use in case of emergency, is there any reason why they should not be used continuously, and thus utilize, each trip, the advantage of the increased haulage capacity (this being the service for which patentees claim that traction-increasers were designed)?

6. If they are useful at low speeds, is there any reason why they cannot be made just as useful at high speeds?

7. (*a*) Are you familiar with any schemes for increasing traction other than those known as Dees, Purves, Craven (automatic traction draw-bar), and the Locomotive Improvement Company's?

(*b*) Would not the simple application of screw and lever (as used in European practice to increase the weight on a single driving-axle), accomplish the desired end as effectively as the above-mentioned designs?

8. Have engines regularly using traction-increasers developed any special failures in springs, spring gear, side rods, cylinders, loose tire or special wear on tires, or in cracks in frame, horns and horn-stays?

9. Give any information possible as to first cost, cost of application and cost of repairs to traction-increaser, also additional outlay or estimated saving in the cost of general repairs of engines fitted with a traction-increaser.

This Committee would like to have their report in the hands of the Executive not later than the last day of April, 1888.

J. DAVIS BARNETT,
F. L. WANKLYN,
T. J. HATSWELL,
} Committee.

Replies should be addresssd to J. Davis Barnett, Mechanical Superintendent, Grand Trunk Railway, Port Hope, Ontario.

EXTENSION SMOKE-BOXES AND FIRE-BOX ARCHES.

It is a recognized fact that the railroad interest of this country is passing through a crisis unequaled in its history, and it is plain that it becomes the duty of all interested to aid in its safe passage. The fuel consumed by locomotives, together with the expense of adjusting fire claims caused by fire thrown from locomotive stacks, are two of the larger items of expense connected with railroad operations.

Extension Smoke-boxes and Brick and other Fire-box Arches is a subject bearing directly on the above points, and it is asked as a duty of each and every member of the Association, and of all having charge of railroad machinery, to assist the Committee in getting out an intelligent and reliable report by answering as clearly and fully as possible the following questions:

1. What kind of fuel is used on your locomotives; hard coal, soft coal or wood?

2. What is the average amount of water evaporated per pound of the coal you are using?

3. What is your average cost per locomotive-mile for fuel?

4. What form of smoke-box is used on your locomotives?

5. Have you had any experience with the so-called "extension fronts"? If so, please give dimensions of the same, with sketch showing location and kind of netting, and situation of deflector plate, if any used, also situation of exhaust nozzles and arrangement for discharging sparks.

6. What form of smoke-stack do you use in connection with the extended front? In the same connection, please state size of engine cylinders, size of nozzles, dimensions of fire-box and number of flues.

7. Do you advocate the use of single nozzle in connection with the extended front?

8. Have you had any experience with a device in the ordinary box that would accomplish the same end as that claimed for the extended front? If so, please state results obtained and send drawings of the same, and state if, in connection, any extras are used in fire-box as well as showing smoke-stack construction.

9. Do you favor the use of a draft or petticoat pipe in connection with the extended front?

10. What is the amount of additional weight caused by extended front and attachments?

11. How do you regard the old style smoke-box and diamond stack in economy of maintenence, economy of fuel and preventative of fires as compared with the extension fronts and attachments?

12. Have you used a fire-brick arch or other device in fire-box in connection with extended front? If so, please give dimensions of same, with sketch showing the device and manner of sustaining it, and the results obtained as compared with the plain fire-box in the same connection.

13. Do you favor the use of a brick or other arch in the fire-box of a locomotive using bituminous coal, and can you say from experience that the advantage gained thereby will warrant the expense of maintaining such arch?

14. Have you noticed any injuries to fire-box sheets resulting from the use of a fire-box arch? Please send drawing of the fire-box grates used in connection with your extended front.

15. Under what circumstances, if any, do you advocate the use of hollow stay-bolts in fire-box for the purpose of admitting air above the fire?

16. All things considered, do you favor extended fronts on locomotives as now generally constructed? If not, please state objections.

Please do not confine yourself to the questions asked, but, with your advice and aid of drawings, give the Committee any information you may possess bearing on the subject.

JOHN HICKEY,
W. A. FOSTER,
E. L. WEISGERBER,
} Committee.

Answers should sent to John Hickey, Master Mechanic, Wilwaukee, Lake Shore & Western Railroad, Kaukauna, Wisconsin.

Master Car-Builders' Association.

THE following circular has been issued from the Secretary's office, dated November 15:

"The report of the Executive Committee of the Master Car-Builders' Association having been approved by the Association, and the Janney Type of Coupler having been made the Master Car-Builders' Standard, a sub-committee has been appointed by the Executive Committee to consummate the recommendation of the report that the Association procure one of the present makes of Janney Type of Coupler, selection being made by a committee appointed for that purpose, and then all other forms of couplers that will couple to and with this coupler, under all conditions of service, are to be considered as within the Janney Type and conforming to the standard of this Association.

"All parties who claim to manufacture couplers within the Master Car-Builders' Type are requested to send two couplers, completely finished and ready for service, to R. D. Wade, Superintendent of Motive Power, Richmond & Danville Railroad, 1300 Pennsylvania Avenue, Washington, D. C., on or before December 13, 1887. Such parties are further requested to send a representative, to appear before the Committee on the above date and at the above place, who will with proper drawings describe the mechanical construction of the coupler he represents, such drawings to remain with the Committee and become the permanent property of the Master Car-Builders' Association.

"If in the judgment of the Committee it should become necessary to attach the couplers to cars, the Committee will provide cars and facilities for testing, but all expenses incident to attaching the couplers must be defrayed by the owners of the couplers.

"The Committee will not consider models or drawings of couplers not represented by full-sized couplers ready for attachment to cars as above described.

"The Committee will make their report to the Executive Committee, who will issue drawings of the Master Car-Builders' Type, and officially announce the names of the couplers which are within this type.

"The members of the Master Car-Builders' Association are invited to meet with the Committee and assist them in their investigation of the various couplers.

"EDWARD B. WALL,
"R. D. WADE,
"JOHN S. LENTZ,
"J. W. CLOUD,
} "Committee."

PERSONALS.

Mr. P. A. Smith is now Resident Engineer on the Texas & Pacific road.

Mr. C. E. Marvin has been appointed Roadmaster of the Central Railroad of Georgia.

Mr. R. C. Peebles has resigned his position as Superintendent of the Mexican National Railway.

Mr. H. Tandy has been appointed Superintendent of Motive Power of the New York, Ontario & Western Railroad.

Mr. J. D. Letcher is Chief Engineer of the Ohio & Northwestern road, with headquarters at Portsmouth, Ohio.

Mr. C. H. Mead has been appointed Master Car-Builder of the Texas & Pacific road, with office at Marshall, Texas.

Mr. E. Canfield, late Division Superintendent, is now Chief Engineer of the New York, Ontario & Western Railroad.

Mr. F. L. Stevens has been appointed Chief Engineer of the Main Line Division of the Philadelphia & Reading Railroad.

Mr. Edmund Yardley is now Superintendent of Transportation of the Pennsylvania Company's lines, with office in Pittsburgh.

Mr. Joseph Wood has been appointed General Superintendent of Transportation for all the Pennsylvania lines west of Pittsburgh.

Mr. George L. Potter is Master Mechanic of the Pennsylvania Company's shops at Fort Wayne, Ind., succeeding F. D. Casanave, promoted.

Mr. J. T. Dodge has resigned his position as Chief Engineer of the Montana Central Railroad. His present address is Duluth, Minnesota.

Mr. C. W. Lanpher, late Division Superintendent, is appointed Superintendent of Transportation of the New York, Ontario & Western Railroad.

Ex-Governor Benjamin F. Prescott has been appointed Railroad Commissioner of New Hampshire, succeeding E. J. Tenney, whose term has expired.

Mr. Benjamin Thomas, lately on the New York, Lake Erie & Western, is now General Superintendent of the Chicago & Atlantic road, with office in Chicago.

Mr. F. D. Casanave has been appointed Superintendent of Motive Power of the Pennsylvania Company's lines (west of Pittsburgh) and will have his office at Fort Wayne, Indiana.

Mr. Theodore Scheffler, of Paterson, N. J., is now in Germany, introducing the Rotary Steam Snow-shovel on the Saxon State railroads. The order for the first or sample plow has been given; it will be built in Saxony.

Mr. A. Gottlieb has taken an interest in the Mt. Vernon Bridge Company at Mt. Vernon, O., and will act as Consulting Engineer. He will also retain his connection with firm of A. Gottlieb & Co., and his office in Chicago.

Mr. Michael Rickard, of Utica, has been appointed a Railroad Commissioner of New York to succeed John D. Kernan, resigned. Mr. Rickard is a locomotive engineer on the New York Central road. He was nominated for the office last winter, but not confirmed.

Mr. A. K. Mansfield, Mechanical Engineer, has removed his office from Chicago to New York, and has established himself there at No. 280 Broadway (Stewart Building) in company with Mr. George L. Mansfield, under the firm name of A. K. Mansfield & Company.

Mr. John Bogart was elected State Engineer of New York on November 8. The State thereby gains a most capable and efficient public officer; it is to be hoped that the American Society of Civil Engineers will not lose the services of an excellent Secretary.

Mr. James McCrea, late Manager, has been made Fourth Vice-President and General Manager of the Pennsylvania Company, the Pittsburgh, Cincinnati & St. Louis Railway Company and the Chicago, St. Louis & Pittsburgh Railroad Company. His office will be in Pittsburgh.

D. J. Whittemore, of Milwaukee; **Joseph M. Wilson,** of Philadelphia, and **Alfred P. Boller,** of New York, form a committee of engineers selected to report on the long-discussed question of providing proper terminal facilities in Providence, R. I., for the railroads entering that city.

NOTES AND NEWS.

An English Electric Yacht.—The new yacht *Countess*, which is claimed to be the largest vessel to which electric propulsion has yet been applied, has had several successful trials near London. The boat is 90 ft. long and has a screw 3 ft. 6 in. diameter and 5 ft. 6 in. pitch, which is to run 200 revolutions a minute. The motor is of the Elieson pattern.

French Iron Production.—The total production of pig-iron in France in 1886 was 1,507,850 tons. The production of manufactured iron was 767,214 tons and of steel 466,913 tons. There was a slight decrease in each item. The steel production included 348,299 tons of Bessemer and 89,755 tons of open-hearth steel.

During the year there were 20,014,597 tons of coal mined in France; 8,366,205 tons of coal and 1,059,282 tons of coke were imported.

English Consumption of Iron Ore.—The amount of iron ore used in Great Britain last year is given by official returns as follows, in tons:

	1886.	1885.
Mined in Great Britain	14,110,013	15,418,082
Imported from other countries.....	2,878,469	2,822,598
Total.....	16,988,482	18,240,680

Nearly all the imported ore—2,646,089 tons—came from Spain. Algeria supplied 165,554 tons, and only insignificant amounts came from other countries.

Signals at Sea.—The New York Maritime Exchange has prepared a memorial to the President, requesting him to take measures to bring about an international conference for the purpose of arranging an improved system of signals to be used by ships at sea, the system now in use being considered crude and imperfect.

Should such a conference be called, it is suggested that several other subjects might be considered, among them the concerted use of naval vessels of all nations in securing improved charts, etc., life-saving service, and the removal of derelict wrecks at sea.

The Military Prize Essay.—Lieutenant E. R. Hills, Assistant Secretary of the United States Military Service Institution, has issued the following notice:

"At a meeting of the Executive Council of the Military Service Institution, held on Governor's Island, October 20, the following was selected as the subject for the prize essay of 1887: 'Organization and Training of a National Reserve for Military Service.'

"The object is to open for discussion the general question of how a national reserve force available should be organized and how it should be trained by annual manœuvres or otherwise, for immediate service."

Train Lighting Extraordinary.—We have seldom seen a more remarkable or original notion put forward in a responsible quarter than that contained in a French specification filed by *La Société pour le transport de la force par l'Electricité*, as a method of lighting railway carriages by electricity. This is the company of which M. Marcel Deprez forms so distinguished an ornament. The proposal is to place a small windmill upon the roof of each carriage, and so to provide motive power for the usual paraphernalia of dynamos, secondary batteries and glow-lamps. As to the prospects of success of this scheme, while, of course, we shall hope for the best, yet we are prepared—we may say *fully* prepared—for the worst.—*London Electrician.*

A Palace Street-Car.—The Gilbert Car Manufacturing Company has nearly completed a street car for Dom Pedro of Brazil, which is to be the most expensive car of that description ever built. The body of the car is of paneled mahogany inside and out, and all metal work showing is gold plated. The car is about the size of an ordinary street car and has four windows on each side, the glass being very heavy French plate. The windows have curtains of brocatel inlaid with cloth-of-gold. The roof is surmounted by a dome which is of jeweled glass, furnished by Tiffany, of New York. The furniture of the inside consists of two divans upholstered with cloth-of-gold, and four large arm-chairs of rattan gilt, and provided with curtains of silk plush. The wooden panels inside are covered handsomely, the crown of Brazil being a prominent feature. The floor is covered with the finest Wilton carpet, and all the accessories are of the finest kind, even the water-cooler being gold-plated. This car is probably the finest specimen of work of the kind ever turned out.

Finding a Lost Car.—A very singular loss and recovery occurred recently on the Union Pacific near Laramie. A special freight, running psseanger time, broke in two on the

hill, and the front section ran around a sharp curve so fast that it whipped off the rear car, filled with choice Chinese silks, into the gulch, where it disappeared from sight in the heavy brush. The break was so clean that the two sections were coupled without the single car's absence being noticed. For two months that car lay there, while the entire road was being searched far and near for it. The other day a cowbow rode into a small station on the line and casually asked when they were going to clear up that wreck down in the gulch. The agent knew of no wreck, and thought the cowboy was fooling with him, but at last, convinced he was in earnest, went with him to the spot. There, at the bottom of a very deep fill, behind a huge pile of boulders and a mass of sage brush, lay the missing car, No. 99. It was resting on its side, and strange enough, the trucks were in proper place. The doors were sealed, and there was nothing beyond a few bruises and dents in the roof and sides to show that there had been any rough treatment experienced.—*Omaha Republican.*

Blast Furnaces of the United States.—The tables compiled by the *Iron Age* give the condition of the blast furnaces on November 1 as follows:

	In blast.		Out of blast.	
Fuel.	Furnaces.	Weekly capacity.	Furnaces.	Weekly capacity.
Charcoal	70	12,344	103	8,864
Anthracite	124	40,028	74	17,111
Bituminous and coke	151	90,459	56	17,901
Total	345	142,831	233	43,876

The *Iron Age* comments as follows: "On the whole, October has been rather an uneventful month for the pig-iron industry of the United States, so far as fluctuations in the capacity actively at work are concerned. There has been very slight falling off in anthracite pig production, and a slight gain in coke iron, the aggregate make being very heavy. So far as reports bearing on the immediate future are concerned, they do not indicate any decided movement, either in the direction of a restriction or of an expansion. Indeed, it may be said that the current production is very close to the maximum capacity, considering the slight inducements which are offered by present prices as related to costs."

Beton Forts.—It is known that the new fortifications at Antwerp have been built on new plans, adopted for the purpose of meeting the progress of modern artillery, and especially to provide against the use of the improved projectiles.

The explosion of shells of the latest patterns is very destructive to masonry walls, as was shown at Cummersdorf and the fort of Malmaison. Accordingly engineers have been led to substitute beton or concrete for brick or stone masonry in those parts of a fortification which are exposed to the fire of siege guns.

At the fort of Schooten, which is part of the advanced line of defense at Antwerp, all the casemates are of beton. These casemates are 3 meters in thickness at the crown of the arch, and it is believed that they will be strong enough to withstand the effect of any fire.

It may be noted that the extreme precision and the long range of modern siege guns have made it necessary to abandon almost entirely the defense of forts by guns *en barbette* or in the open air. For this reason all the heavy guns are now covered or placed in casemate, and for defense against assault smaller rapid-firing guns and machine-guns or mitrailleuses are provided.—*Revue Scientifique.*

Car Service Charges.—The Pennsylvania Railroad Company has made the change in charges for freight-car service which was recommended by the Car Accountants' Association, substituting a mixed mileage and per diem charge for the simple mileage charge (¼ cent per mile) heretofore made. The new system took effect October 1, and its details are given in the following order:

"1. The mileage rate shall be ½ cent. per mile and 15 cents per day per car for each day, Sunday included.

"2. The rate on four-wheel cars shall be ¼ cent per mile and 7½ cents per day.

"3. No per diem charge to be paid on cars delivered and returned the same day.

"4. Days to be counted from one day to another, that is, a car received on April 1 and delivered on April 5 equals 4 days.

"5. The per diem charge on cars shifted by one railroad for another, for the purpose of receiving or discharging lading, shall be paid by the road on which the switching is done.

"6. The per diem rate shall be paid on cars in shops, and on cars destroyed, until date of notice to owners."

Other prominent companies have signified their intention of adopting the same system, which will probably come into general use.

Excavation by Dynamite.—*Le Genie Civil* gives an interesting account of the use of dynamite for sinking holes in wet ground for foundations. It has been successfully used in building the fortifications around the City of Lyons. The foundations for the walls were to be built in an alluvial soil, constantly inundated by the River Rhone, and composed of shifting sand. It was necessary to sink two meters to find good ground on which to build. Eight cartridges of dynamite, containing each 100 grammes, were exploded together, resulting in a hole 1.10 meters diameter. In this a metal cylinder was sunk, the hole then cleared out, the concrete filled in, and the cylinder withdrawn.

Three points are especially interesting in this matter.

1. The explosion makes a hole shaped like the frustum of a cone, 1.00 to 1.20 meters in diameter, with a depth equal to 75 per cent. of that required, on account of the earth falling in.

2. The explosion compresses the surrounding earth to such a degree that the walls of the hole remain vertical long enough to clean out the hole and put in the concrete.

3. The water is driven back so far that it does not begin to again filter through the walls for half an hour.

This operation was so expeditious that in a single day of 10 hours 5 holes 2 meters deep were sunk, cleaned out and concreted, and the work of laying foundations on them was begun. The foundation was 24 meters long.

A Russian War-ship.—A new Russian ironclad, modeled on the *Impérieuse* of the English Navy, has just arrived at Cronstadt from the Baltic Engineering Works at St. Petersburg, to receive her artillery, etc., aboard, preparatory to being attached to the Baltic fleet. The *Admiral Nakhimoff* is 333 ft. long (the *Impérieuse* is 315 ft.), 61 ft. broad (the *Impérieuse* is 62 ft.), and has a displacement of 7,782 tons as compared with the 7,390 tons of the English vessel. The contract for the ironclad was signed in July, 1884, and the launch took place in October the following year. Last October the official trials took place, when the engines (two triple-expansion engines of 4,000 I. H. P. each) worked up to 4,500 H. P. and realized a speed of 17½ knots. The hull of the *Nakhimoff* is built entirely of Russian metal, the steel being manufactured at the Putiloff Works at St. Petersburg. The armor-plating, which ranges in thickness from 6 in. to 10 in., was rolled at the Kolpina Steel Works, where Messrs. Cammell & Co. have established an armor rolling-mill for the Russian Government. Without armor and fittings the hull has cost $1,310,000; the engines, without auxiliary mechanism, $640,000. The pumps are of the Gwynne description, and the fire engines are being supplied by Messrs. Shand & Mason. The two torpedo cutters, which the ironclad carries, have been built by Messrs. Crichton & Co., of Abo, Finland. The machine guns used are of the Hotchkiss description, and the vessel is fitted with a tube for discharging 15-ft. Whitehead torpedoes. In general, the Russians are very pleased with the new addition to the Baltic fleet, and claim that during its construction advantage has been taken to rectify the defects which practice has brought to light in connection with the *Impérieuse.*—*Engineering.*

The Manchester Ship Canal.—At the recent meeting of the British Institute, Mr. E. Leader Williams, Engineer of the Manchester Ship Canal, read a paper on the canal. At the outset he mentioned that, after unsuccessful attempts in the years 1883 and 1884, acts of Parliament were obtained in the sessions of 1885, 1886 and 1887, which gave the Manchester Ship Canal Company power to construct a large ship canal from the deep water at Eastham, near Liverpool, to Manchester. The Board of Trade having certified that the conditions in the Acts relating to capital had been complied with, the contract for the whole of the works had been let to Mr. T. A. Walker, of Westminster, and the construction of the canal would be commenced as soon as the arrangements, now in progress, for the purchase of the lands required were completed. The canal would be of greater bottom width than the Suez, Amsterdam or any other ship canal, and it would absorb the whole of the waters of the rivers Mersey and Irwell, and their tributaries, between Manchester and Warrington. From Eastham to Warrington, a distance of 20 miles, the tidal water of the Mersey estuary would be impounded on one level by large entrance locks at Eastham. The depth of the water in the canal would vary with the height of the tide, but would never be less than 25 ft. The minimum bottom width of the canal would be 120 ft., or nearly 45 ft. more than the Suez Canal. Above Warrington, large ship locks would be constructed at Latchford, Irlam and Barton, to raise the canal to the level of Manchester. The total length of the canal would be 35½ miles. Docks, quays and basins would be constructed at Manchester, Barton, Warrington, Partington and Weston Point. The existing docks at Runcorn, now the pro-

perty of the Manchester Ship Canal Company, were connected with the canal and would afford the means of developing the trade of Staffordshire and the Potteries. The docks at Weston Point and Ellesmere Port were on the canal. The Bridgewater canals recently purchased by the Ship Canal Company were in connection with the proposed new docks at Manchester, and all the inland canals were in direct communication with the Bridgewater Canal, which would also join the Ship Canal at Runcorn and Barton.

Antarctic Exploration.—The endeavors of the Australian colonies to raise money for resuming explorations in the Antarctic regions have so far been unsuccessful. The funds for rewards to whalers extending their cruises beyond the 60th degree of south latitude have not been appropriated, and nothing has been done since Allen Young's offer to take command of an expedition of this kind. Sir Graham Berry has, in accordance with instructions from the Government of Victoria, asked the British Government to contribute the sum of £5,000 toward an Antarctic expedition, provided the Australian colonies agree to contribute an equal sum, and the subject is now under consideration. The financial state of the colonies is not very good at the present time, and therefore it is not likely that any energetic attempt will be made. The movement for resuming these explorations originated in Germany; but so far nothing has been done there to raise money and send out an expedition, as the activity of explorers is almost exclusively directed toward Africa and the islands of the Pacific Ocean.

Our American whalers are those who have the most immediate interest in the matter, as they frequent the neighboring seas and obtain considerable quantities of whale-oil from that region. A few years ago one of them landed on Graham Land and found near its shores an abundance of sea-animals; but as he had no authority to visit those dangerous latitudes, and as the ice was closing upon his ship, he did not continue his explorations. We do not think that the endeavors of the Australian colonies will be successful for some time to come, and it would be gratifying if, meanwhile, American enterprise would take up this important problem, in which no nation is more interested than we are, as our vessels are those which visit Antarctic waters most frequently, and as a successful approach is most probable close to the south point of our continent.

Arctic navigation shows that progress is always most promising under the shelter of land. Graham Land can be reached with comparative ease; and under its shelter, that is, on its eastern coast, important discoveries can be made without great risk and at no great expense. This would be a task for one of our whaling-masters who navigate year after year the ice-covered waters of the Arctic Ocean in their stanch and swift schooners.—*Science.*

Barge Building in Russia.—While Russia is not a builder of iron vessels for sea-going or, with rare exceptions, for river purposes, owing to the collapsed condition of the ship-building industries, she still turns out every year an immense number of wooden craft of considerable magnitude. If a steamer of 800 tons is a very large one for her to produce, and is only produced occasionally, she constructs every season wooden barges with the enormous cargo capacity of 8,000 tons for service on the Volga. Barges for canal purposes, as small as those used in this country, are scarcely ever seen in Russia. The average Russian barge conveys as much cargo as the average English coasting cargo ship. Plying regularly on the River Volga, season after season, are 3,000 permanent barges of 1,000 tons cargo capacity apiece, making a united cargo capacity of 3,000,000 tons. These are very strongly built, almost clumsily so, but answer the purpose for which they are intended—to carry cargoes to the Great Fair at Nijni Novgorod, and convey others back again to the various navigable branches of the River Volga. In excess of these, 200 barges are built on the Kama and Volga every year, intended only to carry goods to the destination and then be broken up, ranging in cargo capacity from 5,000 to 8,000 tons. Occasionally even barges of 10,000 tons cargo capacity are seen at the Great Fair. Such mammoth vessels are built in the autumn and winter, and float with the spring floods down rivers unnavigable in summer to the Volga, where they are taken in tow by steamers and conveyed to Nijni Novgorod. Their length—300 ft. or 400 ft.—unfitting them for traversing the canal system between the Volga and St. Petersburg—the locks accommodating only vessels 147 ft. long—1,000 smaller barges of 200 or 300 tons capacity are constructed specially for this purpose, being used afterward at St. Petersburg and other towns for firewood, etc. On the Volga also the barge builders turn out 4,000 ferry barges, fishing boats and small craft of various kinds every year. Formerly a large number of three-masted wooden vessels for the Caspian used to be built annually, but the rapid extension of the steamer service there has checked this branch of the industry. While in England canals have long been under a cloud in Russia the construction of railroad has very little agecied their traffic, and they are undergoing constant development.—*Engineering.*

A French Submarine Boat.—Vice Admiral Bourgeois is claimed in France as the first inventor of the submarine boat many years ago, and its prototypes, including the American *Peacemaker* essayed in other nations, are counted as but so many adaptations of the original idea. Dismissing any argument on the point, our present attention is engaged upon a diving vessel which is to be made at Toulon, and whose keel was laid as far back as April last on the slips of the Mourillon Docks. The lines of the new craft are due to M. Ramazotti, a first-class sub-engineer of the French Navy, and whose design is fast approaching completion. Shaped like a cigar, on the Winans type, the hull measures 55 ft. from end to end, and the widest beam is exactly 6 ft. The immersion of the vessel in controlled by means of leaden plates disposed along her sides, and when afloat only from 16 to 18 ft. of the crown of the shell will be visible above water. From the center of this part rises a small dome with bull's-eye ports around, and from the interior of the receptacle, the vessel is guided upon its course or made to sink or swim at the will of the commander within. The motive power is imparted by a Krebs electric motor of 50 H. P. which will work twin screws up to the estimated speed of 10 knots. The internal divisions of the hull and framework or fittings are of brass or red copper, and all the other machinery, excepting the screw actions, will be dependent upon compressed air from cylinders containing about 100 atmospheres in store. Room is also found within the shell for a considerable provision of respirable air for the crew, which includes the commander, 12 engineers and 3 seamen.

To sink the vessel to varying depths beneath the surface, water in requisite quantity is to be pumped into reservoirs, and to direct a straight course, an ordinary rudder in the usual position is employed, but to shape a vertical progress there are rudders hinged about one-third the length of the boat at the sides, aft, or just before the counters. With these adjuncts the rise or descent and oblique course of the hull are controlled, and in the supposition of a near approach, unobserved and scatheless, to a hostile vessel, the powers of destruction become available. The compressed-air tubes will enable the commander to launch two torpedoes of small size but terrific force from the diver. The two engines are linked together by a wire loop, and another wire connected with the battery in the boat pays out on their discharge. The diver withdraws from the spot, and, at a convenient moment, the explosion is effected with all safety of the assailants under water. It is stated that an automatic diving boat of similar nature has been successfully tried in Russia, during some operations on the Neva before the Czar.—*The Broad Arrow.*

Modern Sieges.—At the last meeting of the Military Service Institution on Governor's Island, N. Y., Captain J. G. D. Knight, U. S. Engineers, read a paper on the Attack and Defense of Modern Fortifications and the Latest Experience and Principles in Modern Sieges.

"The first point to settle is what can be considered modern sieges," began the lecturer, and then he briefly referred to Sebastopol, Strasburg, Metz and Plevna, and concluded that a modern siege was a siege conducted on both sides with all the methods of modern warfare.

The lecturer then called attention to the siege of Belfort, where all rules, except those relating to countermining and meeting assaults, were exemplified. He then touched upon the development of artillery; that of small arms; the relative effect of artillery and infantry fire, and the modifications of details and methods of fortifications. After this Captain Knight outlined the attack and defense of permanent works, and referred to the same points with respect to field works, touching especially on the use of modified sap work to be used in the attack of the latter.

"The attack and defense of field fortifications," continued the lecturer, "will always be of more importance to us than those of permanent works because of our foreign policy, of the sea-coast location of our permanent works, and, I might add, because of our probable line of operations toward our frontiers in case of war."

During the lecture Captain Knight also referred to the comparative range of ancient and modern firearms, and to the fact that while the modern breech-loader missed fire about 3 shots in a 1,000, the old smooth bore missed as many as 300 to 500, and even 800 in the case of the old flint-lock in wet weather. Captain Knight strongly advocated the use of plunging fire, which he claimed could be used with considerable effect upon defense, when the latter was stationed behind high

parapets and comparatively secure from the effect of direct fire.

In this connection he drew illustrations from several instances of attack and defense which occurred during the Russo-Turkish war. The lecturer also impressed his hearers with the absolute necessity of strong supports, both in case of an attacking column, which might capture the enemy's first line of defense and find itself exposed to a murderous fire from the second line of defense, giving several illustrations as to how hard-earned advantages had been lost owing to the absence of such support, particularly referring to the check received by General Skobeleff at Gravsetzka.

In the case of attacking columns advancing on an enemy's earthworks, the lecturer drew attention to the fact that much depended upon the general in charge of the attack, who in order to effectively feel the pulse of the attack should be stationed, in spite of the great personal risk, midway between the extreme line of the attack and the reserve, so as to be able to correctly judge the right moment in which to call forward the reserves.

In all attacks, he said, there are the reckless, fearless men, who will rush forward and get killed; the men of moderate courage, who will stand fire for a considerable time, but eventually waver if subjected to severe loss, and lastly, the faint-hearted men, who are ever ready to turn tail to the enemy.

The order to bring the reserves into action, Captain Knight claimed, should be given while the second class of men, the men of moderate courage, were not demoralized, for to wait until they wavered would probably mean defeat.

A New Style of Torpedo-Boat.—The London *Times* says: "The defects of the old second-class torpedo-boats have long been recognized at the Admiralty, where also the desirability of combining in one vessel the speed and power of a torpedo-boat with the general usefulness of a pinnace has been felt. The vessel which was tried yesterday is known as Torpedo Boat No. 50 on the official list, and has been built by Messrs. Yarrow & Co., of Poplar. She is somewhat shorter than the old boats she is intended to supersede, but she has increased beam and freeboard. She is 60 ft. long with 8 ft. 6 in. beam, whereas the old boats are 63 ft. long with only 7 ft. 4 in. beam. The new boat, which has a lifting weight of 11¼ tons, is steel built throughout, with a flush deck, and has a mean draft of 2 ft. 3 in. The forward part is completely covered by a turtle-back designed to throw off the sea. Beneath this turtle-back is a small cabin in which about a dozen men can be accommodated. Aft of the cabin is a low conning tower where the steersman stands, and from which position the officer discharges the torpedo. The whole of the central portion of the boat is occupied, as usual, by the machinery. Aft of the stokehold and the engine room is another small cabin, which will accommodate a dozen more persons, and between it and the stern is the storeroom. The boat is propelled by triple-expansion engines driving a three-bladed screw propeller. The boilers are of the usual Yarrow type, with a copper fire-box and copper tubes. The furnaces are fitted with forced draft, and the working steam pressure is 150 lbs. per square inch. The boat is fitted with a partially balanced rudder. Her armament consists of a revolving torpedo gun which is carried aft and so arranged as to fire over either side of the vessel at any angle it may be desired to train it to. The object here in view is that the torpedo shall be discharged at any angle while the boat is going at full speed, instead of direct ahead as in the old system, which involves the boat being brought almost to a state of rest in the face of the enemy and under the fire of his machine guns. The difficulty of hitting a rapidly moving object compared with one at rest, as demonstrated by recent experiments, points to the importance of keeping the boat at full speed. She will also carry a Nordenfelt two-barrel gun, as used in the English service.

"An Admiralty trial of the new craft took place yesterday, the object being to carefully compare the present boat with the old boats. The trial was therefore made on exactly the same conditions as were formerly adopted, and consisted of a full-speed run of two hours' duration. The Admiralty was represented by Commander Egerton, Mr. Smale, and Mr. Shapcott, and the builders by Mr. Crohn. During the two hours' run six runs were made over the measured mile, three with and three against the tide, with the following results: First run, 14.815 knots; second run, 19.251 knots; third run, 15.126 knots; fourth run, 19.780 knots; fifth run, 14.634 knots; sixth run, 18.274 knots. This gives an average speed of 17.147 knots, which was obtained with a mean of 507 revolutions per minute, and this speed was maintained throughout the two hours' run. The average speed of the old second-class boats was 16.5 knots. It will, therefore, be seen that, notwithstanding that the new boat is heavier, shorter and broader than the old ones, there is actually an advance of speed of over half a knot. During the trial the manœuvring powers of the boat were tested, and were found to be much superior to those of previous second-class boats. She turned the circle in 40 seconds, the diameter being 35 yards. There was an entire absence of heel when turning. Another noticeable point was freedom from vibration. During the trial the machinery worked in every respect to the satisfaction of the authorities."

The Nicaragua Interoceanic Canal.—A Washington letter to the New York *Times* says: "The Nicaragua Canal Construction Company's expedition to survey the proposed canal route, which was to have sailed from New York on November 26, will not sail until the 30th. The engineer corps for the survey has just been completed. Civil Engineer A. G. Menocal, U. S. N. Chief Engineer of the Company, has made his selections with great care. The surveying corps will be divided into seven parties—five land surveying, one hydrographic, and one boring party. Civil Engineer R. E. Peary, U. S. N., will have immediate supervision of the work in Nicaragua. The *personnel* is as follows: Chiefs of Parties—J. Francis LeBaron, Jacksonville, Fla.; Domingo Garcia Cartaya, City of Mexico; Frank P. Davis, Washington; J. W. Pethard, St. Louis; Lieut. W. J. Maxwell, United States Navy; Peter Kolb Hoboken, N. J. First Assistant Engineers or Transitmen—W. V. Alford, Garrettsville, O.; S. G. Holcombe, Washington; F. T. Bernhard, New York; H. C. Miller, Louisville, Ky.; P. H. Bevier, New York; MacDonough Craven, Boston. Second Assistant Engineers or Levelers—Ricardo Molina, Havana, Cuba; J. S. Ford, New York; H. C. Litchfield, Jacksonville, Fla.; Calixto Guiteras, Philadelphia; A. J. Menocal, Washington; E. W. Hunt, Wisconsin. Rodmen—Emil Diebitsch, William McCawley and Perry Fuller, Washington; Enrique Cole, Managua, Nicaragua; Paul Spicer, Winchester, Mass.; Paul B. Cooke and P. V. R. Van Wyck. Chairmen—Louis William Mohuan, D. D. Stratton, John M. Murphy, R. J. Wilson, Henry W. Johnson, Washington; Daniel MacAuley, New York. Clerks—Jacob Crowninshield, New York, and Charles E. Kern, Washington. There will be a number of draftsmen and a medical staff of several experienced doctors.

"The engineers of the party have records that show that they have practiced their profession in many parts of the world, are experienced and well known. Mr. Peter Kolb, of Hoboken, N. J., a chief of party and graduate of the Technical University at Carlsruhe, Germany, has been engaged in various surveys and construction of railroads in Mexico, South America, and the United States. He was for some time employed on the Panama Canal, and had to resign his office on account of the unhealthfulness of the climate. His last work was on the Costa Rica Railroad extension to Carlazo. Frank P. Davis, of Washington, is a graduate of the University of Michigan and was for a short time employed in the War Department as a draftsman. He has been in charge of the location of railroads in Michigan, and for some time was Resident Engineer of the Denver & Rio Grande Railroad. Domingo Garcia Cartaya is a distinguished engineer of Mexico, and has figured prominently in the railroad enterprises of that country. J. Francis Le Baron, of Jacksonville, Fla., has been extensively engaged in engineering enterprises in Florida, having surveyed and estimated for a number of canals through the peninsula and other engineering projects. He is a member of the American Society of Civil Engineers, and Secretary of the Southern Society of Civil Engineers, and the author of standard articles on the "Archæology of Florida." H. C. Litchfield, of Jacksonville, Fla., is an Englishman, and served as a midshipman in the British Navy. He left the service, and, after being graduated as an engineer, accepted employment at Natal, South Africa, and later joined the Cape Colony Government railroad service. He remained in the Colony 10 years, and left the Government service and went to Buenos Ayres, Brazil, as Chief Engineer for the extension of the Buenos Ayres & Ensenada Railroad. Later he returned to England, and a year ago came to the United States, where he has been engaged in railroad work. F. T. Bernhard, late Assistant Engineer of the Standard Gaslight Company of New York, is a graduate of the University of Wisconsin, in which State he engaged in the State Geological Survey, and afterward went to Mexico and was employed on the Mexican National Railroad. J. W. Pethard, an Englishman, was formerly an officer in the English Navy, and has been connected with extensive engineering projects in India."

Railroad Accidents in Switzerland.—The Swiss railroad companies report for the year 1886, on 1,734 miles of railroad, 59 train accidents, 42 being derailments and 17 collisions. Of these collisions 10 were caused by misplaced switches or mistakes in signaling. Six derailments resulted from defects of rolling stock and 11 from misplaced or defective switches. The report shows an improvement over 1885, when there were 23 collisions and 63 derailments.